SHIPBOARD ELECTRICAL SYSTEMS

NAVAL EDUCATION AND TRAINING COMMAND

NAVEDTRA 10864-D

PREFACE

This text is written primarily for junior officers of the U. S. Navy and Naval Reserve as an aid in gaining more knowledge of the electrical equipment and electrical systems installed aboard Navy ships. Representative equipments and systems are described by the use of pictoral views and block diagrams with electrical schematics being kept to a minimum. The operating principles of any of the electrical or electronic devices or circuits mentioned in the text may be found in Basic Electricity and NAVPERS 10086-B or Basic Electronics, NAVPERS 10087-C. Information relating to shipboard machinery other than electrical and the organization and administration of the engineering department is contained in Principles of Naval Engineering, NAVPERS 10788-B and Engineering Administration, NAVPERS 10858-E.

This text provides hints on managing the maintenance of generating equipment, distribution systems, motors, controllers lighting systems, degaussing systems, auxiliary equipment, alarm and warning systems, ships indicating and dead reckoning equipment, telephone systems, amplified voice systems and gyrocompasses. Safety precautions required in maintenance and operation of the above equipment and systems are stressed.

This text was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida for the Chief of Naval Education and Training (CNET) personnel. Technical assistance was provided by the Electrical Schools located at Great Lakes, IL, Norfolk, VA, and San Diego, CA.

Stock Ordering No.
0502-LP-054-3250

Revised 1976

Published by
NAVAL EDUCATION AND TRAINING SUPPORT COMMAND

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON, D.C.: 1976

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CHAPTER 1

SAFETY

In accordance with article 0712 of U.S. Navy Regulations the commanding officer is vested with the responsibility of safety aboard his ship. In this regard, he is to ensure that all personnel under his command are instructed in, and comply with, applicable safety precautions and procedures. While the commanding officer cannot delegate his responsibility, he must necessarily delegate authority to his officers and petty officers to ensure that all safety precautions are understood and, more importantly, enforced. As Division Officers you will be required to thoroughly understand all safety notices and instructions and have your division or department comply with them.

Some of your sources of safety information are: Navy Safety Precautions for Forces Afloat, OPNAV INSTRUCTION 5100.19; NAVSHIPS' Technical Manual, Chapter 300; Electronics Installation & Maintenance Book (EIMB) General, NAVSHIPS' 0967-LP-000-0100; How to Keep Electricity from Killing You, NAVSHIPS' 0981-LP-052-8500; Electric Shock Its Cause & Prevention, NAVSHIPS' 0900-LP-007-9010; Electric Shock and Its Prevention, NAVSHIPS' 0283-LP-236-0000; Safety Notes from NAVSEA Journal & Ships Safety Bulletin; EM 3 & 2, NAVEDTRA 10546, and Fathom Magazine published by Naval Safety Center, Norfolk. You should be familiar with all of these publications and ensure that your division or department complies with their contents.

All safety information in this chapter is extracted from the above listed publications. The information contained herein should be used for general guidance and not as final authority.

ELECTRICAL HAZARDS

Probably more deaths aboard ship occur from electric shock than from any other type of accident. Prevention of electric shock aboard ship necessitates strict compliance with all safety requirements pertinent to the various work areas as well as strict adherence to all prescribed safety precautions for the type of job concerned.

ELECTRIC SHOCK

Flow of current through the body is the cause of electric shock. Factors determining the extent of the body damage which results from electric shock are (1) the amount and duration of the current flow, (2) the parts of the body involved, and (3) the frequency of the current, if a.c. In general, the greater the current or the longer the current flows, the greater will be the body damage. Body damage is also greatest when the current flow is through or near nerve centers and vital organs. For example: If a 60-hertz alternating current is passed through a man from hand to hand, or from hand to foot, and is gradually increased from zero, the following effects will occur:

1. At approximately 1 milliampere (0.001 ampere) the shock will be perceptible
2. At approximately 10 milliamperes (0.01 ampere) the shock will be sufficiently intense to prevent voluntary control of the muscles and the man may be unable to let go or free himself
3. At approximately 100 milliamperes (0.1 ampere) the shock will be fatal if it lasts for 1 second.

High frequency currents have a tendency to flow along the surface of the skin (skin effect); persons coming into contact with these currents usually suffer severe burns although the current may not penetrate the body.

Two conditions must be present for an electric current to flow through the body and cause electric shock.

1. The body or some part of the body must form part of a closed circuit; and

2. Somewhere in the closed circuit there must be a voltage, or a difference in potential, to cause a current flow.

It follows, then, that to prevent electric shock, you should always ensure that your body never forms a part of a closed circuit.

Tests made by the National Bureau of Standards show that the resistance of the human body may be as low as 300 ohms under unfavorable conditions such as those caused by salt water and perspiration. These test results indicate immediately that it is possible for a potential difference as low as 30 volts to cause the fatal 0.1 ampere current flow through the body. It is true that the conditions of the above tests were extremely unfavorable. However, the results leave no doubt as to the dangers relative to the 120-volt circuits aboard ship and as to the necessary precautions that all personnel must observe continually.

Causes of Electric Shock

Practically all electric shocks are caused by human failure rather than by equipment failure. Equipment may suddenly fail and cause fatal shock even if it were skillfully designed for safety, thoroughly tested before use, and used in accordance with applicable safety precautions. This can happen, but rarely does. Nearly all shipboard deaths due to electric shock have been caused by human failure manifested in one or more of the following ways:

1. Unauthorized use of, or unauthorized modifications to, equipment.
2. Failure to observe the applicable safety precautions when using equipment or when working on or near energized equipment.
3. Failure to repair equipment which is known to be defective and has previously given a mild shock to users.
4. Failure to test and inspect equipment for defects, or failure to remedy all defects found by tests and inspections.

All of these failures may be summarized as failure to observe applicable safety precautions.

SAFETY TRAINING PROGRAM

The fields of electricity and electronics demand an effective safety training program because of the inherent hazards. Technicians working with the electrical systems are generally aware of the safety precautions but, due to familiarity, sometimes "overlook" them. In this respect a vigorous training program is not just a good idea; it is a MUST.

There are many systems and plans to guide you in implementing a safety training program. You will find some excellent ideas in Standard Organization and Regulations of the U.S. Navy, OPNAVINST 3120.32 and in the Division Officers Guide.

The training plan you select is not as important as that you have a system and make it work to have a safety-conscious division.

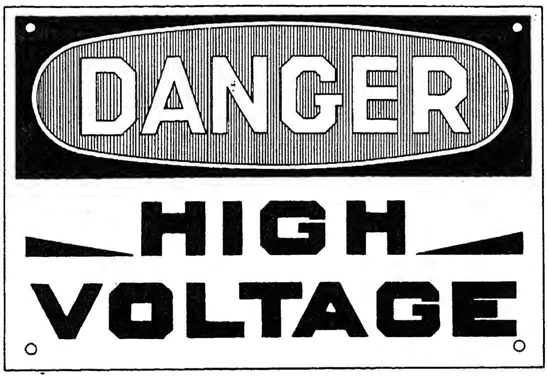
SAFETY REQUIREMENTS

As a division officer of the electrical department aboard ship, you will be dealing with some special tasks which are unique to the electrical field. A basic understanding of these situations will prove helpful to you in maintaining safety precautions within the division.

IN WORK AREAS

Safety requirements concerning the various shops and other work areas aboard ship are prescribed by the NAVSHIPS' Technical Manual and other authority. The requirements for electrical work areas include the following:

1. Rubber matting that meets military specifications is to be provided in the front and rear of all electrical switchboards including IC and weapons control switchboards. This rubber matting is also required in front of all announcing system amplifiers and control racks, on areas around electronic equipment, and in front of test benches or tables in electrical and electronic shops. The matting should be cemented to the deck except on grating and removable deck plates.
2. HIGH VOLTAGE signs (fig. 1-1) and suitable guards are to be provided wherever the voltage exceeds 30 volts in exposed live circuits or equipment.
3. All rear service switchboards are required to have an expanded metal enclosure with a door. The enclosure is NOT to be used as a storage space. A safety poster, such as shown in figure 1-2, posted on the door might be a good reminder.



40.67(31)
Figure 1-1.—High voltage warning sign.

4. First aid treatment (fig. 1-3) for electrical ıock and other applicable electrical safety ·ecautions must be posted in all areas containing ajor units of electrical or electronic equipments.

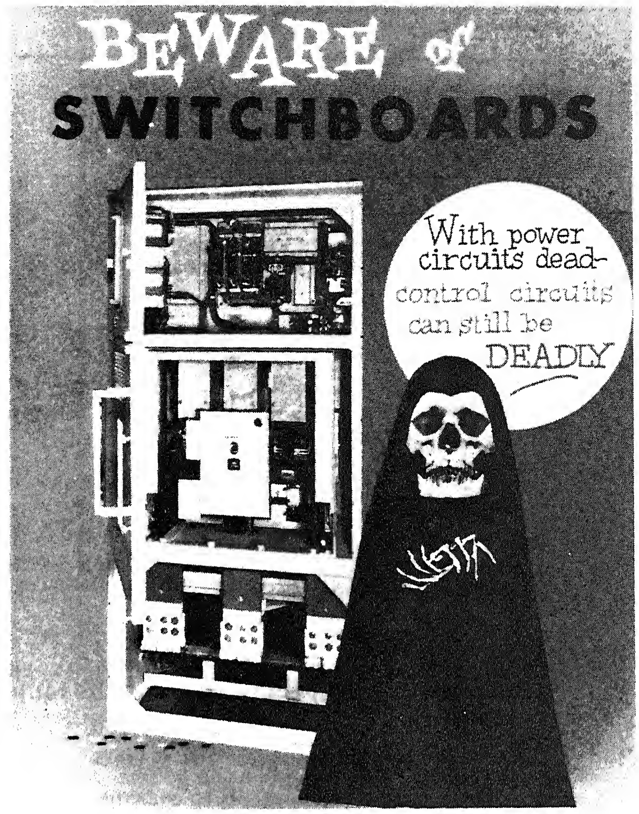
5. NO SMOKING signs are to be posted in ›aces where storage batteries are charged ıd in all other spaces where explosive vapors ay be present.

6. Workbenches must be insulated (fig. 1-4) ; prescribed by General Specifications for ıips of the U.S. Navy, NAVSHIPS' 0902-001-500.

warning plate which reads, ELECTRIC SHOCK—ANGER—DO NOT TOUCH ENERGIZED CIR-UITS must be installed over the workbench. rtificial respiration instructions and a ›scription of an approved method (fig. 1-5) rescuing personnel in contact with energized rcuits must also be posted.

[PORTABLE
LECTRICAL EQUIPMENT

Navy specifications for metal-cased portable ols require that the electric cord for the tools ; provided with a distinctively marked grounding ›nductor in addition to the conductors that ıpply power to the tool. Past practice was to ;e red for the grounding conductor in three-›nductor cables for portable tools and equipment ıd green in four-conductor cables, except for a w cases in which black was used in the cords r some items of portable equipment. Revised ›ecifications require that green be used for e grounding conductor in cables for all new



40.67(67B)
Figure 1-2.—Safety poster.

metal-cased portable tools and equipment. The end of the grounding conductor which is within the tool should be connected to the metal housing, the other end should be grounded; that is, connected to the ship's metal structure. To provide a convenient means of connecting the grounding conductor to ground, NAVSEA has standardized the use of grounded-type plugs and receptacles which automatically make this connection when the plug is inserted into the receptacle.

Nonconducting case-type portable electric tools (plastic-cased, shockproof) do not require grounding cords or plugs. The two-conductor cords and two-prong ungrounded connector plugs furnished on these plastic-cased tools are acceptable and can be inserted into blade-type receptacles aboard ship which may be labeled "WARNING: Insert 3-prong grounded plugs only."

Before using portable electrical equipment for the first time, check the plug connections of the equipment for correct wiring. The test of

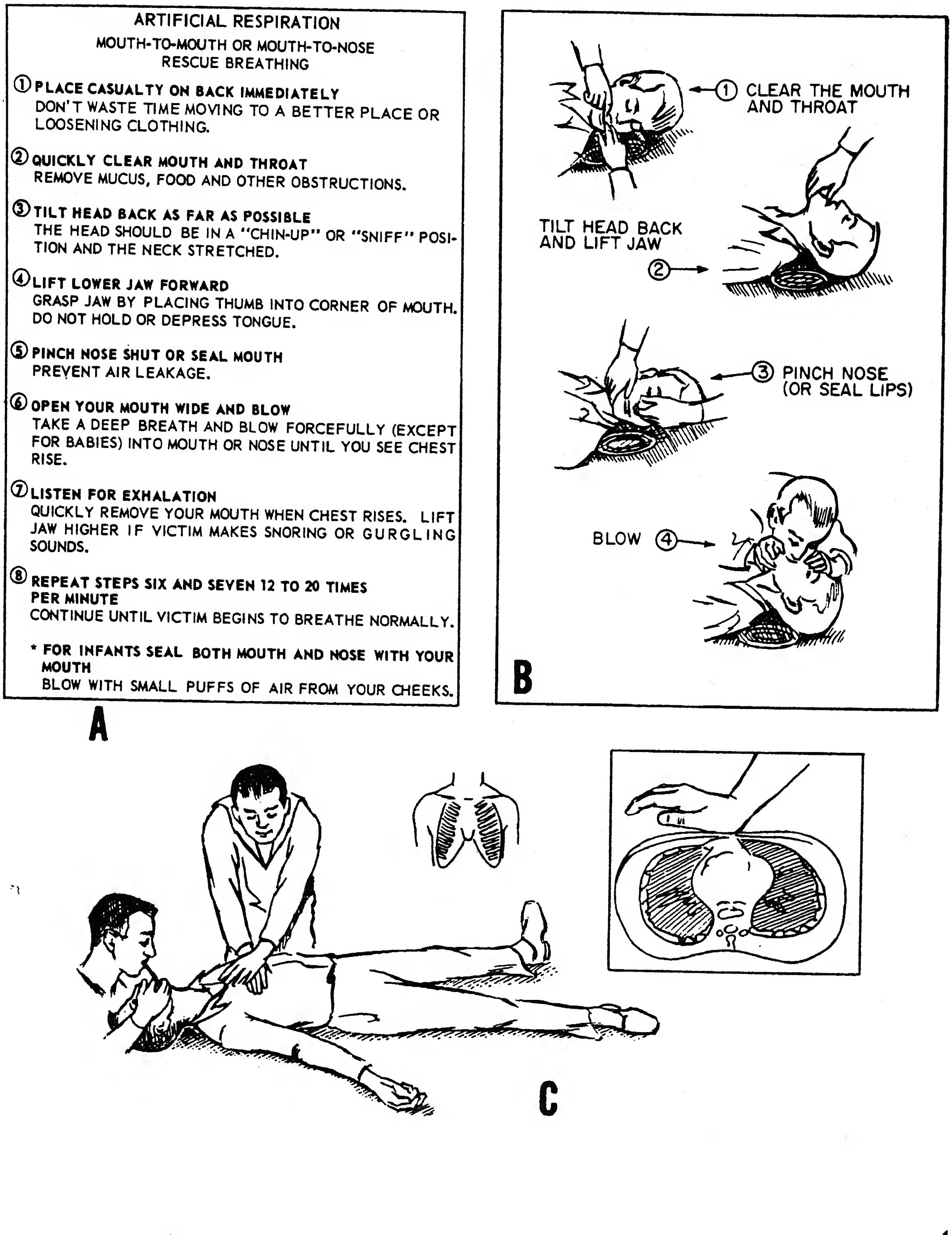
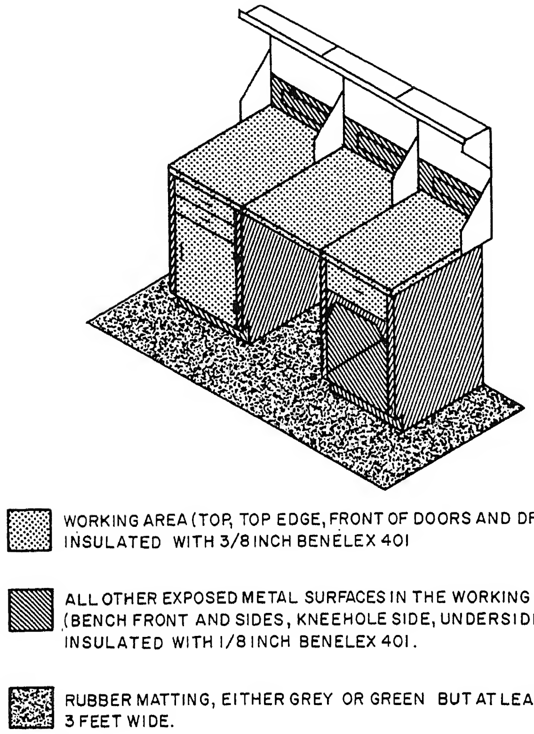
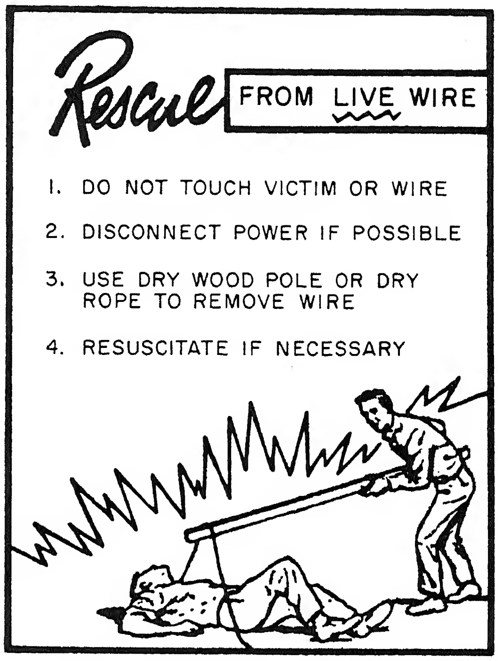


Figure 1-3.—Artificial respiration and cardiac massage. 4.224



77.308
Figure 1-4.— Typical electric workbench.



40.67(27D)
Figure 1-5.— Safety poster.

portable equipment should be conducted in a workshop equipped with a nonconducting surface workbench and a diamond-tread, rubber deck covering. Electricians making the tests should wear rubber gloves during tests.

CONNECTING AND DISCONNECTING SHORE POWER

Because of the variety of shore power arrangements and hardward items used in both ship and shore installations, no specific installation instructions can be outlined in detail in this manual. However, there are instructions and procedures that should be followed before and during connection to shore power. More detailed instruction is usually provided by type commanders or your own ships instruction.

Because of the dangers to personnel and equipment, the connecting and disconnecting of shore power should be under the direct supervision of the electrical officer, a qualified leading electrician, and the shore activity personnel.

All cables should be visually inspected for any signs of defect, such as, cracks, bulges, or indications of overheating. (Spliced cable is extremely dangerous unless splices are properly made.) Check the cables with a 500 V meggar for insulation resistance between phases and from each phase to ground.

Rope off the work area surrounding the ship's shore power terminal box and tag with high-voltage signs. With the ship's shore power breaker tagged in the open position, test the terminals in the terminal box to ensure they are deenergized. With a 500 V meggar, test the insulation resistance between the terminals and from each terminal to ground.

Lay out the cable between the ship's terminal box and the terminal box supplying power from the shore activity, remembering to allow slack for tides. Cables should not be permitted to rest on sharp or ragged objects. Excess cable should be neatly faked out in a manner that will minimize damage from vehicle and pedestrian movement. Connect the cables to the ship's shore power

terminals according to the phase or polarity markings in the box and on the cables.

With a voltmeter, check to ensure that the supplying activity's shore terminals are de-energized; then connect the cables to the shore terminals.

Check for proper phase rotation by energizing the shore power breaker from the supplying activity. With proper phase rotation determined, proceed with the transfer of electrical load to shore power in accordance with Engineering Department Operating Instructions.

After the cables are carrying the load, make an inspection of the cable and connections to detect any overheating.

When disconnecting shore power, observe the same safety precautions outlined in the connecting sequence except for meggering cables and checking phase rotation. <u>ENERGIZED SHORE POWER CABLES SHOULD NOT BE MOVED</u>.

IN USING CLEANING SOLVENTS

Avoid using solvents for cleaning electrical equipment as much as possible because of their corrosive action, the possible injury to some insulating materials, the risk of fire, and especially because of their toxicity.

If it is necessary to use a solvent, the choice of solvent will depend on the instructions on the solvent label, the fire risk involved, and the facilities for maintaining adequate ventilation. It might be beneficial to try a small amount on the insulation to determine whether it will be injurious to the insulation.

Inhibited methyl chloroform (1,1,1 trichloroethane) is the solvent approved for use on electrical equipment to remove grease and pasty substances consisting of oil and carbon or dirt. This solvent is toxic and should be used with care since concentrations of the vapor are anesthetic and can be fatal. Dangerous concentrations of the vapor may cause irritation of the eyes, dizziness, or disorientation. If any of these symptoms occur, you will know immediately that the amount of methyl chloroform being breathed is dangerously high. Personnel must secure the operation and evacuate the space until proper ventilation is obtained. To avoid misuse of this solvent, surface ships shall stock only 1-quart containers.

Precautions with Cleaning Solvents

During the use of any solvent the following rules MUST be observed:

1. Guard carefully against fire.

2. Use explosion-proof portable lights if supplementary lighting is required.

3. Have fire extinguishers available for immediate use.

4. Prevent possible sparks caused by one metallic object striking another.

5. If a spray or atomizer is used, ground the nozzle.

6. Avoid saturation of the operator's clothing with the solvent. Wear impervious (solvent resistant) gloves to avoid contact with the skin. Wear appropriate eye/face protective devices when splash hazards exist (e.g. when pouring solvent, etc.)

7. Provide adequate ventilation by means of exhaust fans or other suitable means.

8. When inhibited methyl chloroform or trichloroethane is being used, protection must be provided against breathing the fumes, and the operators should be under the observation of someone familiar with artificial respiration.

9. Use of solvent in closed or very confined spaces, where ventilation is lacking and for some reason cannot be provided, requires that fullface air supply respirators and related controls be used. (Refer to damage control procedures involving use of "buddy" system, lifelines, etc.).

10. Where normal (comfort) ventilation is present and very small volumes of cleaning solvent are used (few ounces, at most), the minimum requirement is proper use of approved organic vapor (charcoal) respirators. The procedure MUST be studied to minimize exposure to the user, to adjacent spaces, and to nearby personnel.

11. Where larger volumes of solvent are used indoors, specially applied exhaust ventilation and fullface air supply respirators, or equivalent respiratory protection, are recommended.

12. When portable exhaust ventilation is applied, the exhaust face (exhaust end of the flexible duct system) must be placed near the operation for best capture of the "fumes." The direction of ventilation should be checked to

assure that fumes are being exhausted from the space and that the exhausted air is discharged topside away from personnel and openings to prevent recirculation of the fumes into other occupied interior spaces.

13. Do not apply solvent to hot equipment or use it in the presence of open flames.

14. Assure that solvents are properly labeled according to hazards, that they are stored properly, and that adequate marking/labeling is carried over into any subdivisions or transfer of material into other containers.

IN MAINTENANCE AND REPAIR WORK

When military considerations require that electrical repair or maintenance work be performed but prohibit deenergizing the circuits involved, extreme measures of precaution must be used. The work should be accomplished only by adequately supervised personnel who are fully cognizant of the dangers involved. Every care should be taken to insulate the person performing the work from ground and to use all practical safety measures. The following precautions should be taken when applicable:

1. Provide ample illumination.

2. The person doing the work should not wear wrist watch, rings, watch chain, metal articles, or loose clothing which might make accidental contact with live parts or which might accidentally catch and throw some part of his body into contact with live parts. Clothing and shoes should be as dry as possible.

3. Insulate the worker from ground by means of insulating material covering any adjacent grounded metal with which he might come in contact. Suitable insulating materials are dry wood, rubber mats, dry canvas, dry phenolic material, or even heavy dry paper in several thicknesses. Be sure that any such insulating material is dry, has no holes in it, and has no conducting materials embedded in it. Cover areas sufficiently to permit adequate latitude for movement by the worker in doing the work.

4. Cover all metal, hand-held work tools with an electrical insulating material. Taping method: Cover the handle and as much of the shaft of the tool as practical. Use two layers of rubber or vinyl plastic tape, half lapped. Coating Method: Coat tools with plastisol.

In an emergency, when time does not permit application of the above materials, cover the tool handles and tool shafts with cambric sleeving, synthetic resin flexible tubing, or insulation tubing removed from scraps of rubber electric cable.

5. Insofar as practical, provide insulating barriers between the work to be done and any live metal parts immediately adjacent to the work.

6. Use only one hand to accomplish the work, if practical.

7. Use a rubber glove on the hand not used for handling tools. If the work being done permits, wear rubber gloves on both hands.

8. Have men stationed by circuit breakers or switches and have the telephone manned if necessary, so that the circuit or switchboard can be deenergized immediately in case of emergency.

9. A man qualified in mouth-to-mouth resuscitation and cardiac massage for electric shock should be immediately available while the work is being done.

10. Energized switchboards are a great source of danger. No work shall be undertaken on energized switchboards unless approval of the Commanding Officer has been obtained.

11. Be sure that the connections of removable test leads on portable meters are tight. The free end of an energized test lead which comes adrift from its meter during a check of live circuits is both a shock and a fire hazard.

WHILE WORKING ALOFT

At times, personnel are required to go aloft for maintenance on running lights, to work on wind direction and intensity equipment, etc. Aside from the obvious hazard of falling from the mast, certain other hazards exist: asphyxiation from stack gases, electric shock, overexposure to radiation from radar equipment, contact with rotating or oscillating antennas, and overexposure to inclement weather conditions.

Because of the numerous hazards, permission to go aloft must be obtained from the Officer of the Deck. Before granting permission, the OOD shall ensure that all power to appropriate radio and radar antennas is secured and that the controls associated with the antenna are tagged "Secured, Men Aloft." The OOD shall notify ships tied alongside of his intent to send men aloft and they will maintain the same safety precautions. The OOD shall also notify the Engineer Officer of the location of the men working aloft so he can take the necessary precautions to prevent such operations as lifting boiler safety valves or blowing tubes or whistles.

Before sending any men aloft, the Officer in Charge shall ensure that the men have read and that they fully understand all the regulations and safety precautions involved in going aloft.

Some of these regulations are listed below:

1. A man going aloft shall have the assistance of another man.

2. Man working aloft shall wear a standard Navy approved safety harness and safety lines and shall use the saf-t-climb fall prevention system.

3. Do not attempt to climb while loaded with tools. Keep both hands free for climbing.

4. Ensure yourself of good footing and grasp at all times.

5. All tools and equipment shall be secured with preventer lines.

6. Have assistants stand clear and keep all hands clear from below the working area.

7. Men going aloft shall wear tight clothing. Loose or baggy clothing presents the hazard of becoming caught or entangled.

8. When working on the stack, men shall be particularly cautious to avoid dangerous gases and fumes.

9. The Officer of the Deck shall be notified immediately when work aloft has been completed.

NONSTANDARD ALTERATIONS AND EQUIPMENT

Many electrical hazards are introduced to the ship by nonstandard equipment (personal equipment) and nonstandard alterations (jury rigs). Shipboard 115-volt, 60-Hz lighting and receptacle circuits are ungrounded. In an ungrounded system both conductors of the 115-volt system are above ground potential and are a shock hazard. For this reason use of personal electrical equipment, which is normally designed to operate on 115-volt, 60-Hz grounded systems (the normal residential power), is discouraged aboard ship. In much of this equipment the chassis forms a part of the circuit and the exposed metal parts are energized thereby creating the danger of shock to personnel who touch them. Moreover, grounding of these metal parts to the ship's structure would place a ground on the 115-volt system, jeopardizing continuity of power. Personal equipment may be permitted for use aboard ship if the following conditions are met.

a. Adequate government-owned equipment is not available to meet the need.

b. The equipment has been inspected by the electrical/electronic shop and approved as safe. Approved equipment shall be tagged and shall indicate the interval between inspections. The interval between inspections shall not exceed 6 months.

The approval criteria for personal equipment can be found in NAVSHIPS' Technical Manual, Chapter 300.

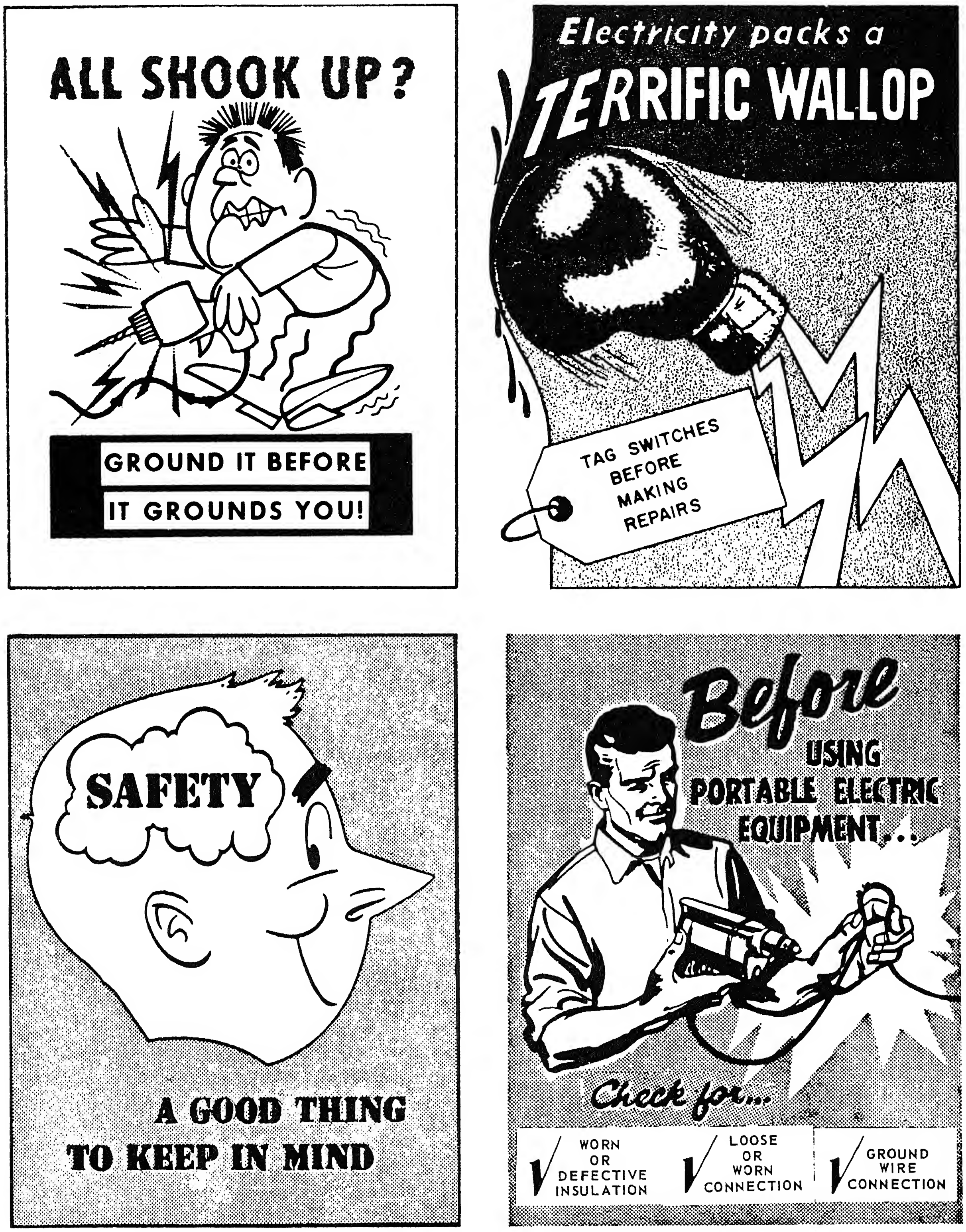
Jury rigs, such as bypassing overloads, overfusing circuits, rendering electrical interlocks inoperative and any other unauthorized design changes to equipment, are prohibited.

SAFETY INSPECTIONS

Conducting frequent informal safety inspections is one of the most effective methods to ensure that precautions and accident prevention measures are being adhered to. These inspections should be used to identify and eliminate the various electrical safety hazards and should be made on a continuing basis.

Some of the more common discrepancies you should look for on your tours are open covers on fuse and power panels, meters not calibrated, circuits over fused, improperly stowed equipment near switchboards, workbenches not properly insulated, and portable electric tools not safety inspected in accordance with PMS.

Electrical safety posters of the type shown in figure 1-6 are useful as safety reminders and in promoting safety. Posters of this type should be changed and rotated regularly to different working areas so as to draw attention to them.



40.67(77C)

Figure 1-6.— Safety posters.

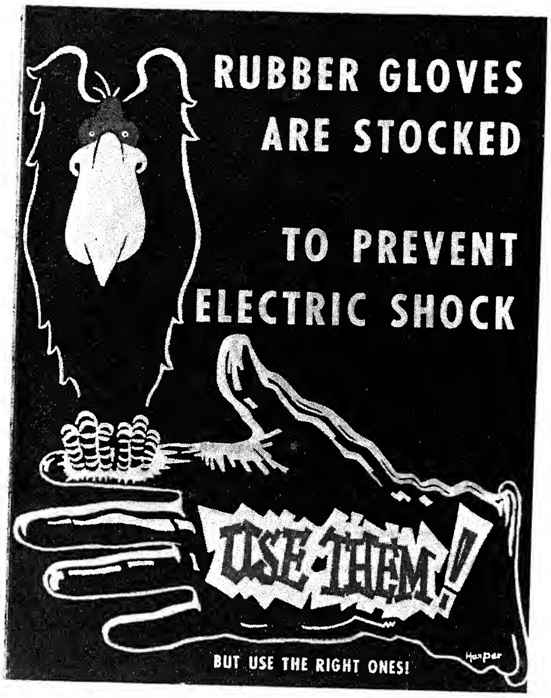


Figure 1-6.—Safety posters—continued. 40.67(67B)

CHAPTER 2

POWER SUPPLIES

Ships of the U.S. Navy use electrical energy for a variety of applications which range from simple lighting circuits to sophisticated and complex weapons circuits and electronic circuits. The electrical power is generated by power supplies.

In this chapter we shall identify the different types of power supplies, their basic operations, their driving units and their regulation. We shall give a basic explanation of how an electrical voltage is generated. You will find more detail in Basic Electricity, NAVEDTRA 10086-B. Similarly, you will find simplified block diagrams to describe functional operations of the closely regulated power supplies that supply power to certain weapons and other electronic systems on modern ships. We will not attempt to show how individual circuits function. You will find information on these circuits in Basic Electronics, Vol. 1, NAVEDTRA 10087-C, NavShips 0967-000-0120, and individual manufacturer's technical manuals.

VOLTAGE PRODUCED BY MAGNETISM

Magnetic devices are used for thousands of different jobs. One of the most useful and widely employed applications of magnets is the production of vast quantities of electric power from mechanical sources. The mechanical power may be provided by a number of different sources, such as gasoline or diesel engines and water or steam turbines. However, the final conversion of these energy sources to electricity is done by generators which use the principle of electromagnetic induction. We shall discuss the fundamental operating principle of ALL such electromagnetic-induction generators.

To begin, there are three fundamental conditions which must exist before a voltage can be produced by magnetism:

1. There must be a CONDUCTOR in which the voltage will be produced.
2. There must be a MAGNETIC FIELD to cut the conductor.
3. There must be RELATIVE MOTION between the field and the conductor. Either the conductor must be moved to cut across the magnetic lines of force, or the field must be moved to cut across the conductor.

In accordance with these conditions, when a conductor or conductors move across a magnetic field so that the lines of force are cut, electrons WITHIN THE CONDUCTOR are impelled in one direction or another. Thus, an electromotive force (emf) or voltage, is produced.

In figure 2-1, note the presence of the three conditions needed to create an induced voltage:

1. A magnetic field exists between the poles of the C-shaped magnet.
2. There is a conductor (copper wire).
3. There is relative motion. The wire is moved back and forth across the magnetic field.

In figure 2-1A, the conductor is moving toward the front of the magnet (note the direction of motion) because of the mechanical force. The right-hand end becomes negative, and the left-hand end becomes positive. The conductor is stopped in figure 2-1B. Motion is eliminated (one of the three required conditions), and there is no longer an induced emf. Consequently, there is no longer any difference in potential between the two ends of the wire. The conductor in figure 2-1C is moving away from the front of the magnet (motion reversed). An induced emf is again created. However, note carefully that the reversal of motion has caused a reversal of direction in the induced emf.

If a path for electron flow is provided between the ends of the conductor, electrons will leave the negative end and flow to the positive end. As shown in figure 2-1D. Electron flow will continue as long as the emf exists. In studying figure 2-1, please note that the induced emf

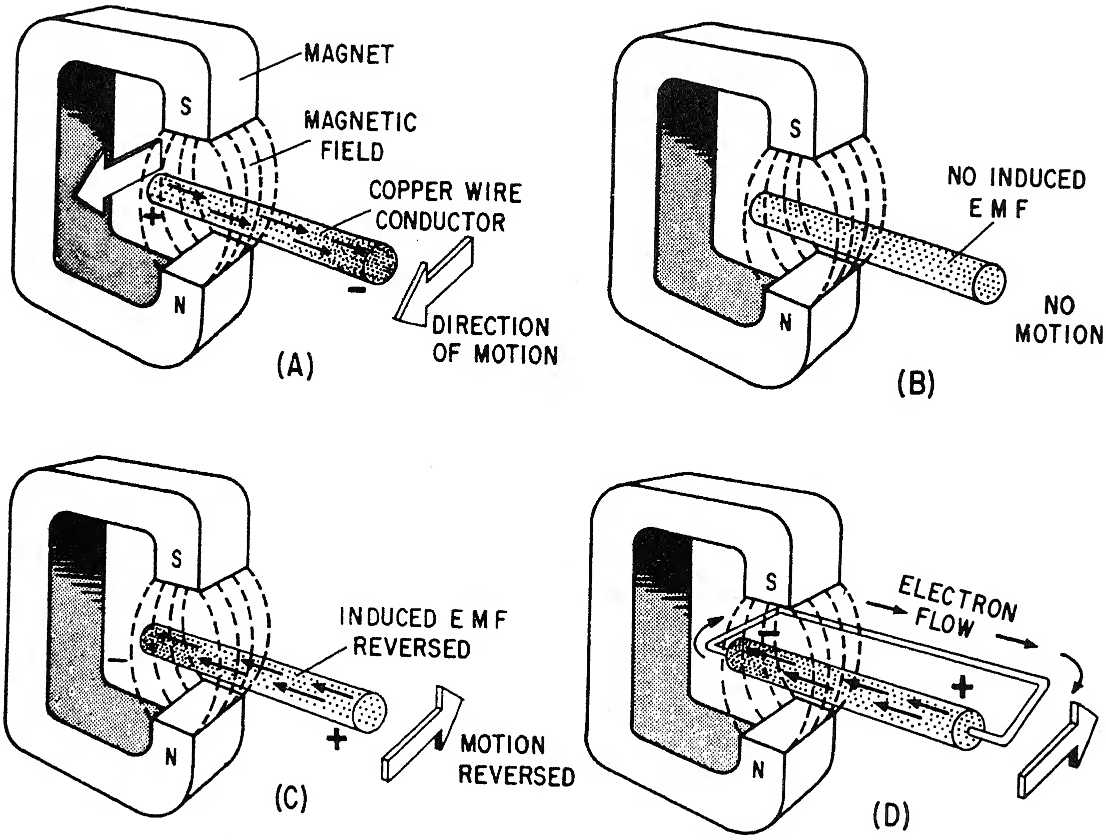


Figure 2-1.— Voltage produced by magnetism. 236.24

could also have been created if the conductor were held stationary and if the magnetic field were moved back and forth.

This basic principle will be used as we discuss the types of generators in this chapter.

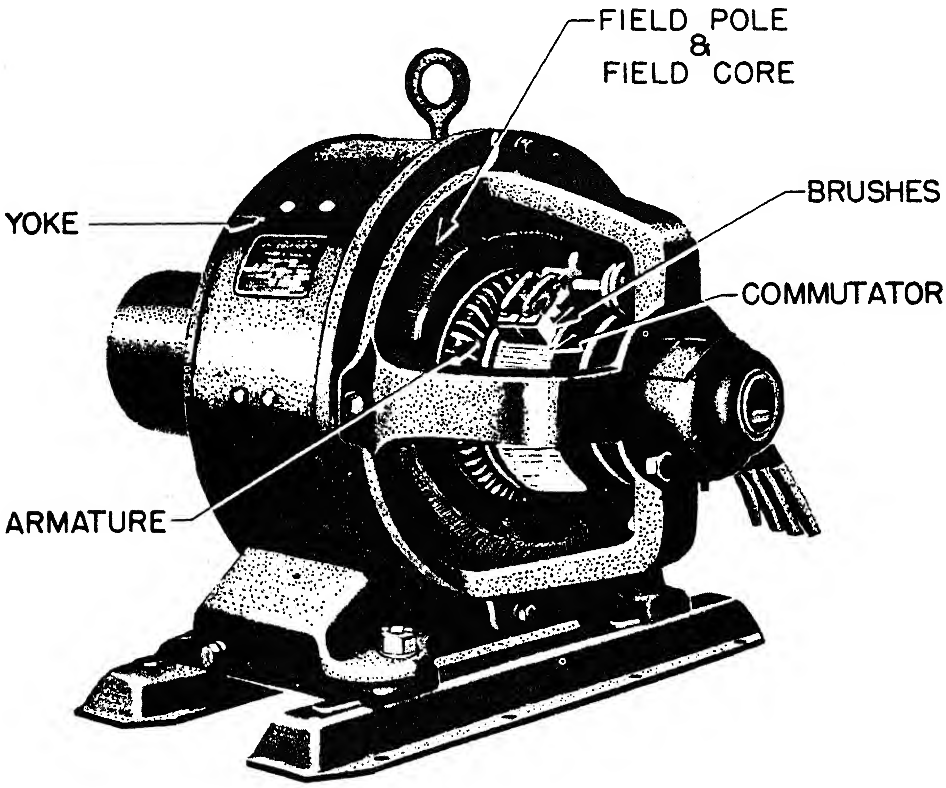
DIRECT CURRENT GENERATORS

Various auxiliaries, amphibious and mine warfare ships, patrol landing and service craft, utilize d.c. generators as the main source of electrical power. A d.c. generator is a rotating machine which converts mechanical energy to electrical energy. Figure 2-2 shows an open-ended d.c. generator. A d.c. generator consists essentially of the following components:

1. A steel frame or yoke containing the magnetic pole pieces and field windings.
2. An armature consisting of a group of copper conductors, mounted in a slotted cylindrical core, made up of thin steel disks called laminations.
3. A commutator to cause the current to flow in one direction through the external circuit.
4. Brushes with brush holders to carry the current from the commutator to the external load circuit.

The d.c. generator must rotate at designed speed to produce the designed voltage. Thus any device that will cause generator rotation is commonly called a prime mover. One of the most common prime movers for d.c. generators is the diesel engine. Figure 2-3 shows a diesel-driven d.c. generator.

The d.c. generator normally used on naval vessels is of stabilized shunt construction, which has inherently good voltage regulation. Basically, voltage regulation is the ability of a generator



236.328(A)

Figure 2-2.—Open-Ended d.c. generator.

:o maintain a constant output (terminal) voltage ınder varying loads. If closer regulation is :equired, a voltage regulator will be utilized.

A voltage regulator consists of a sensing levice and a mechanical or electrical control ›lement to produce changes in the generator 'ield current which are necessary to maintain a ›redetermined constant generator terminal voltage.

ALTERNATING CURRENT GENERATORS

Alternating current generators, normally re-erred to as alternators, are used as the main source of electrical power on all combatant, ınd many other types of Navy ships. With very ew exceptions these alternators are 450-volt, 3-phase, 60-hertz machines.

The alternators (a.c.) are smaller in size and have less weight that d.c. generators. Maintenance requirements are also reduced with a.c.

CONSTRUCTION OF ALTERNATORS

Alternators are usually of the d.c. excited revolving field type. However, small alternators (25 kW and below) may be of the revolving armature type. Salient pole type rotors, which produce a rotating field, are used on alternators of 1800 rpm and below. (See figure 2-4B.)

An amortiseur (damping) winding is provided on salient pole rotors to dampen hunting effects when generators are operated in parallel and to equalize flux distribution when an unbalanced load condition exists. These windings are similar to a squirrel-cage and are placed near the pole face of each field pole.

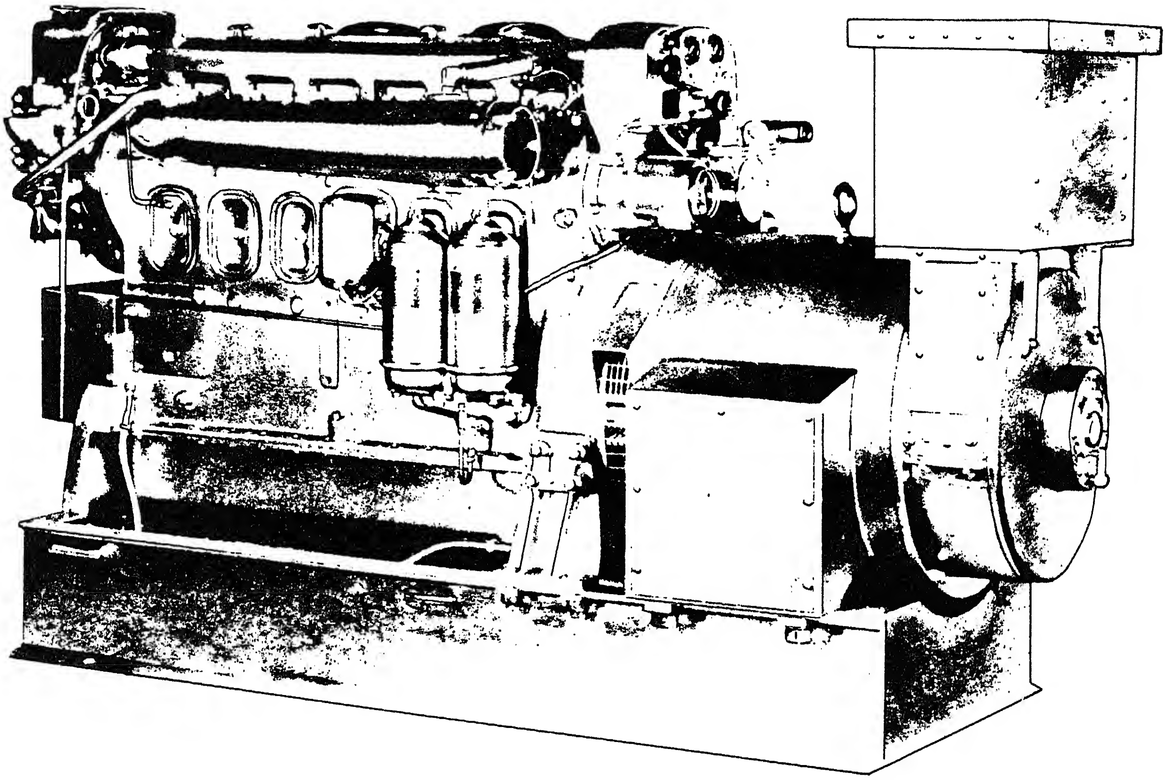


Figure 2-3.—Diesel-driven d.c. generator. 77.70

The cylindrical rotor (fig. 2-5B) is a solid steel forging. Slots in which the field coils are imbedded are milled into the forging. These coils are usually arranged to form either two or four magnetic poles. The diameter of the rotor is small, which, at high speeds, results in better balance, less noise, and less windage. With a small diameter, the rotor length is extended to obtain the required field strength.

TYPES OF DRIVE

Shipboard alternators are driven by steam turbines, diesel engines, or electric motors. (Gas turbines are used in many of the newer installations.) The steam turbines normally operate at 12,000 rpm and drive the alternators through reduction gears. Turbine driven 400-Hz alternators, however, are usually directly connected to the turbine.

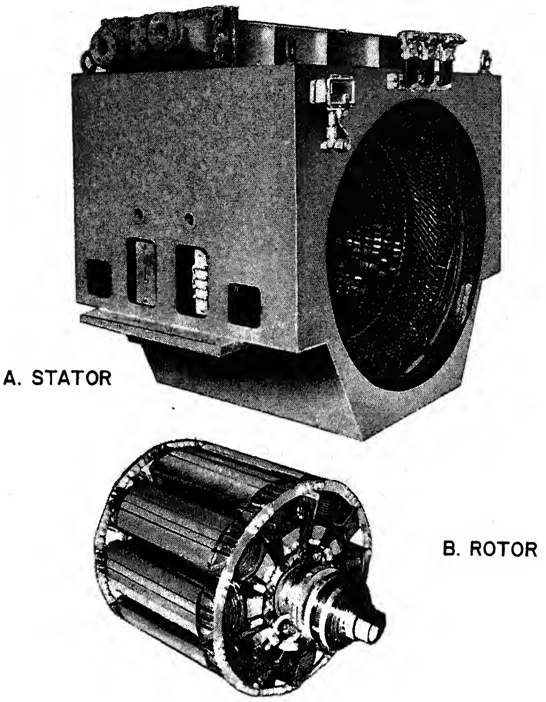
Engine-driven alternators are usually of the salient pole type. The 60-Hz alternators are directly connected, while the 400-Hz installations are usually driven through step-up gears.

Motor-driven alternators are used to convert direct current to alternating current, or alternating current of one frequency to alternating current of a different frequency.

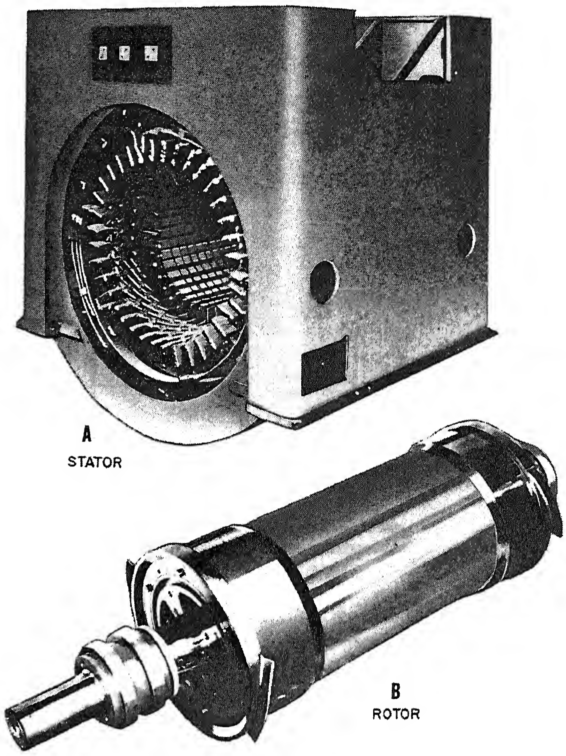
60-HERTZ ALTERNATORS

The 450-volt, 60-Hz, 3-phase alternator installations aboard Navy ships vary in size depending on the power requirements of the particular type ship.

The turbine-driven alternator shown in fig. 2-6 is typical of ship's service alternators found aboard certain frigates. The alternator is rated



139.43X
Figure 2-4.—Low-speed salient pole engine-driven alternator.



139.44X
Figure 2-5.—High-speed turbine-driven alternator.

at 450 volts and produces 750 kW, 3-phase, 60-Hz power at 1200 rpm. The totally enclosed alternator (fig. 2-7) has a double-tube type air cooler located on top of the alternator stator. The stator (fig. 2-8) has six temperature detectors embedded in the slots of the stator to monitor stator temperature during operation. Space heaters are located inside the stator on the lower part of the frame. These heaters prevent condensation of moisture on the windings during shutdown periods.

The alternator rotor (fig. 2-9) is of the salient pole type. It has six poles and two bronze collector rings to apply the d.c. power (revolving d.c. field). As the turbine drives the rotor, the magnetic field of the rotor cuts the coils of the stator to produce a voltage in the stator. The electrical load is connected to the stator.

400-HZ GENERATOR

In modern-day electronics and computers, the need arose for miniaturization of equipment in both aircraft and naval vessels. Experimentation with various frequencies showed that a 400-Hz system would meet these requirements. A higher frequency will produce a higher speed, as well as a higher torque, for a given size motor. Therefore, a smaller size 400-Hz motor can be used without affecting the output.

Experimental efforts proved that the 400-Hz system was unsatisfactory as the sole source of power for shipboard use. This system was found to be impractical for large power applications because of heat dissipation and voltage losses. The 400-Hz system is used in equipment that requires the higher frequencies and wherever the smaller motors are advantageous. The 400-Hz power supplies furnish power for systems such as the gyrocompass, radar, sonar, and fire control circuits. Since 400-Hz power is generated in the same manner as 60-Hz power, no attempt will be made to discuss the generation of 400-Hz.

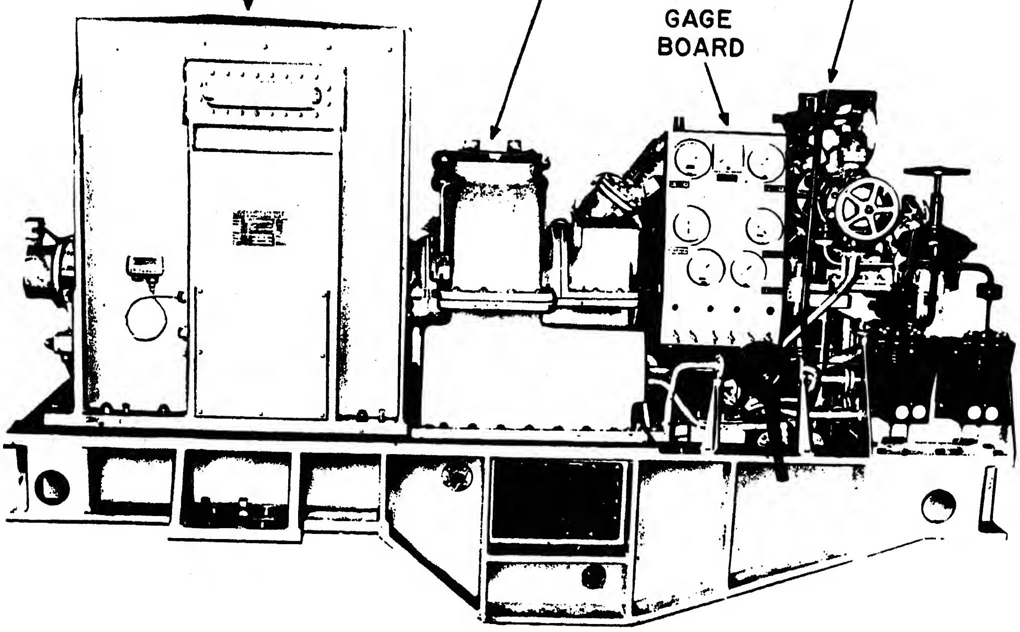


Figure 2-6.—Turbine-Generator (alternator) set.

27.356X

A typical example of a 400-Hz system aboard ship is a 30-kW motor-generator set.

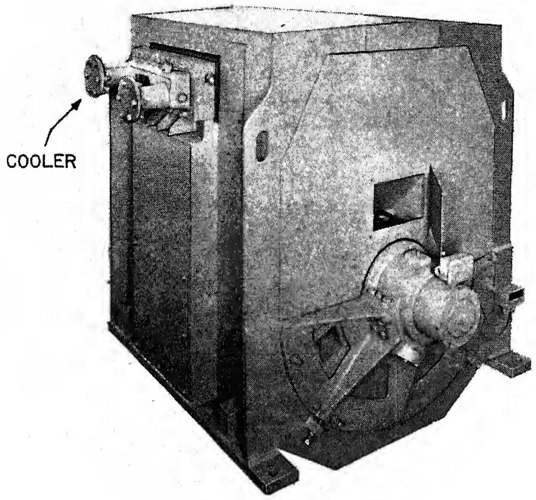
30-kW MOTOR GENERATOR SET

A typical closely regulated motor-generator set (fig. 2-10), consists of a 450-volt, 3-phase, 60-Hz, 50-hp, wound rotor induction motor which drives a 450-volt, 3-phase, 400-Hz, 30-kW generator. The set is regulated and controlled by a voltage and frequency regulating system which is housed in the rotor resistor and regulator unit control cabinets and by a magnetic controller with associated pushbuttons and switches which are located in the control cabinet (fig. 2-10).

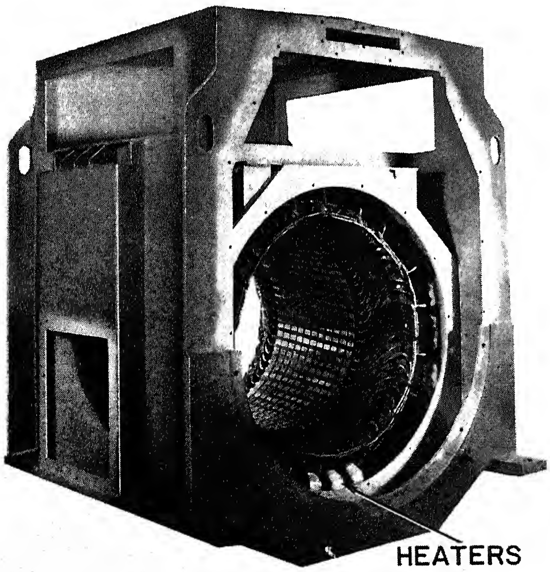
The magnetic controller is a conventional across-the-line semiautomatic motor controller (starter). The voltage regulating system supplies the proper field current to the generator to maintain the generator output voltage to within ±1/2 of 1% of the rated output voltage for all load conditions. The frequency regulating system controls the speed of the drive motor to maintain the output frequency of the generator to within ±1/2 of 1% of its rated value for all load conditions. In addition, power sensing networks are included to eliminate speed droop with increased generator loads and to maintain equal sharing of the load between paralleled generators.

VOLTAGE REGULATORS

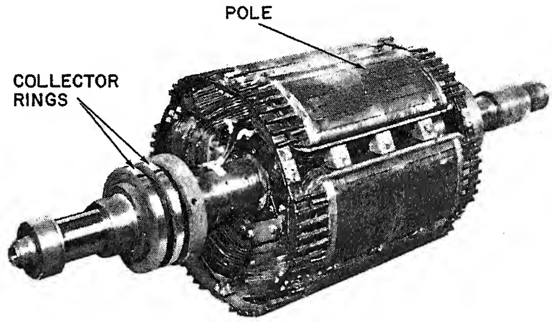
As previously described most d.c. generators have inherently good voltage regulation characteristics. Due to a.c. characteristics alternators have poor voltage regulation. To compensate for this disadvantage, a voltage regulator must be incorporated. There are several types of voltage regulators used in naval vessels—(1) indirect acting rheostatic, (2) direct acting rheostatic, (3) rotary amplifier, and (4) combined static excitation and voltage regulation system—all use the same basic principles. Voltage regulation is accomplished by controlling the amount of current in the generator field. In this chapter we shall give a basic description of the combined



139.44X
Figure 2-7. — Turbine-Driven alternator (cooler shown).



27.85X
Figure 2-8. — Stator.



27.86X
Figure 2-9. — Salient pole rotor.

static excitation and voltage regulation system which is being used on most new construction ships.

COMBINED STATIC EXCITER AND VOLTAGE REGULATION SYSTEM

The combined static exciter and voltage regulation system consists of a (1) static exciter, (2) field flashing circuit, (3) automatic voltage regulator, and (4) manual voltage control.

Static Exciter

The static exciter, fig. 2-11 consists of a 3-phase, bridge rectifier (CR1), three linear reactors (L1, L2, L3), and three saturable current potential transformers (SCPT) (T1, T2, T3). Each SCPT has a current winding, a potential winding, a secondary winding, and a control winding. These are connected in a 3-phase circuit, with the output of the secondary windings rectified and applied to the generator field.

At no load, the input to the SCPT's is from the generator terminal voltage, through the potential windings and linear reactors.

Under load, the line current flowing through the current windings adds a component that is approximately proportional, in magnitude and phase angle, to the voltage in the generator.

The control winding current changes the output of the SCPT by saturating the cores.

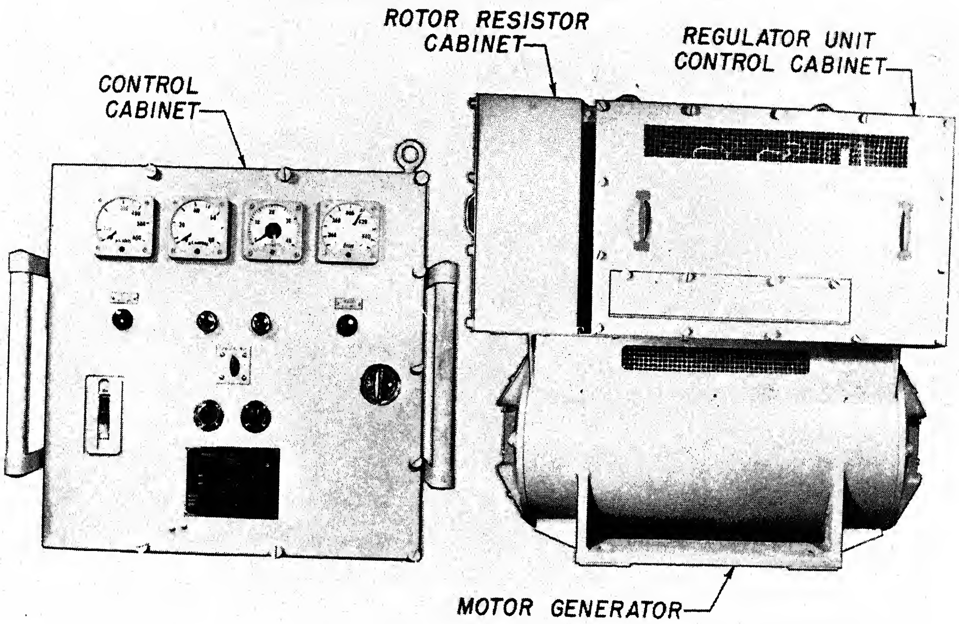


Figure 2-10.—Motor generator set with control equipment. 40.111

Field Flashing Circuit

Since the static exciter cannot supply field current until the generator voltage is built-up, the field flashing circuit provides for the initial voltage buildup. As part of the circuit, a small permanent-magnet alternator (PMA), which is driven by the prime mover, furnishes excitation current through rectifier CR 5 (fig. 2-12).

As the generator starts to turn over, the PMA builds up an a.c. output which is rectified by the 3-phase full-wave-bridge rectifier CR5 and furnishes d.c. to excite the generator field, thus building up a generator voltage.

Automatic Voltage Regulation

The static exciter will not supply the exact amount of field current required to maintain constant generator terminal voltage under all operating conditions because of:

1. The effects of a.c. generator field saturation
2. Changes in field resistance because of heat
3. Changes in ambient temperature
4. Normal manufacturing tolerances

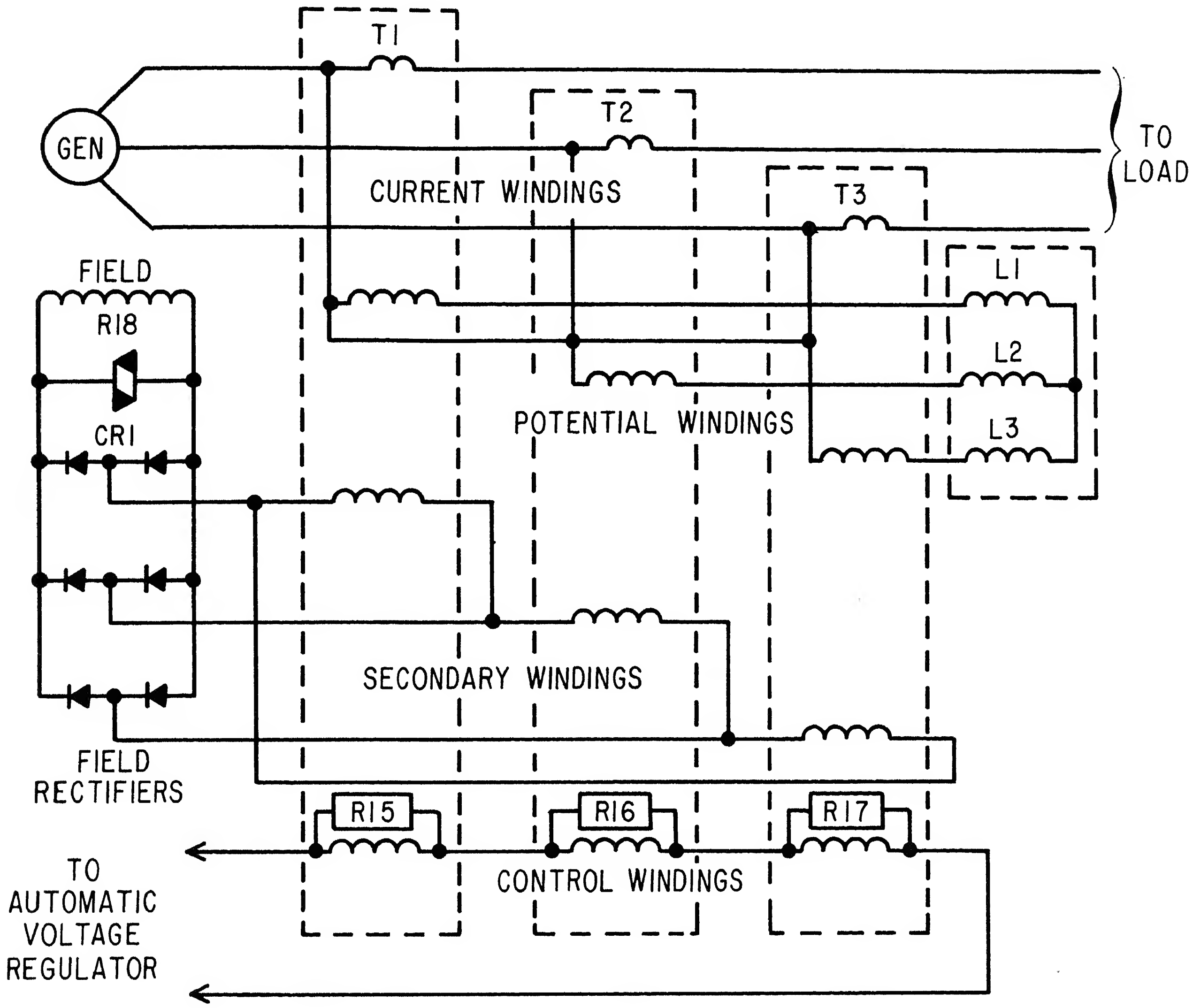
Therefore, the direct-current supply to the control windings of the SCPT's is controlled by an automatic voltage regulator so that the generator terminal voltage is held nearly constant.

For explanation purposes the automatic voltage regulation system is subdivided as follows:

1. Sensing circuit
2. Reference circuit
3. Comparison circuit
4. Magnetic amplifier circuit
5. Stabilizing circuit

SENSING CIRCUIT.—To obtain the best regulation during unbalanced load conditions, a sensing circuit (fig. 2-13) responds to the approximate average value of the three line voltages. This circuit consists of a 3-phase potential transformer (T4), a rectifier (CR4), a reactor (L4), and a capacitor (C1).

Transformer T4 reduces the line voltage to a convenient value and rectifier CR4 converts the 3-phase a.c. voltage to a d.c. voltage. If an



11.30

Figure 2-11.—Static exciter circuit.

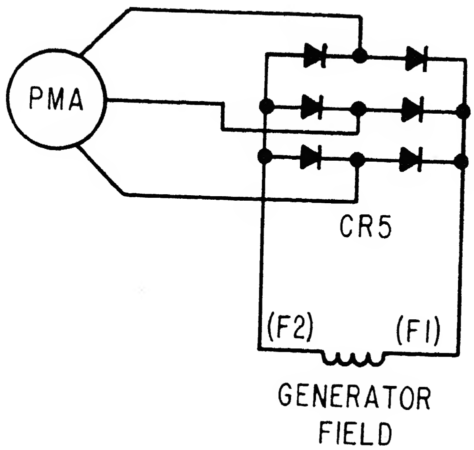
unbalanced load condition causes the three line voltages to become unequal, the d.c. output of CR4 will have considerable ripple. Reactor L4 and capacitor C1 comprise a filter network which averages the varying d.c. output of CR4 so that the voltage across C1 is essentially constant and is approximately the average of the three line voltages.

REFERENCE CIRCUIT.—The reference amplifier (fig. 2-14) supplies a nearly constant reference voltage to the emitter of Q1 in the comparison circuit.

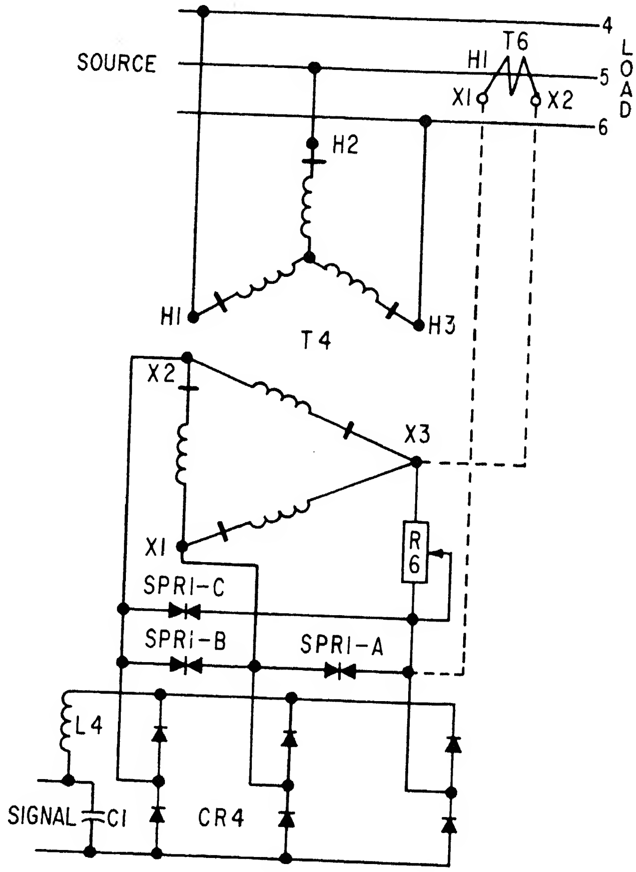
Rectifier CR2 consists of a zener diode, which is a rectifier that operates in the breakdown (or zener) region and has a nearly constant 11.7-volt drop for a large variation in current.

If the voltage applied to R5 and CR2 increases, the current increases, and the increase in voltage is absorbed as IR voltage drop across R5. The voltage across CR2 remains almost constant because of its flat voltage characteristic.

COMPARISON CIRCUIT.—The comparison circuit (fig. 2-14) compares the sensed voltage



11.30
Figure 2-12.—Field flashing circuit.



11.30
Figure 2-13.—Sensing circuit.

with the reference voltage by means of transistor Q1 and acts on the magnetic amplifier to correct any difference.

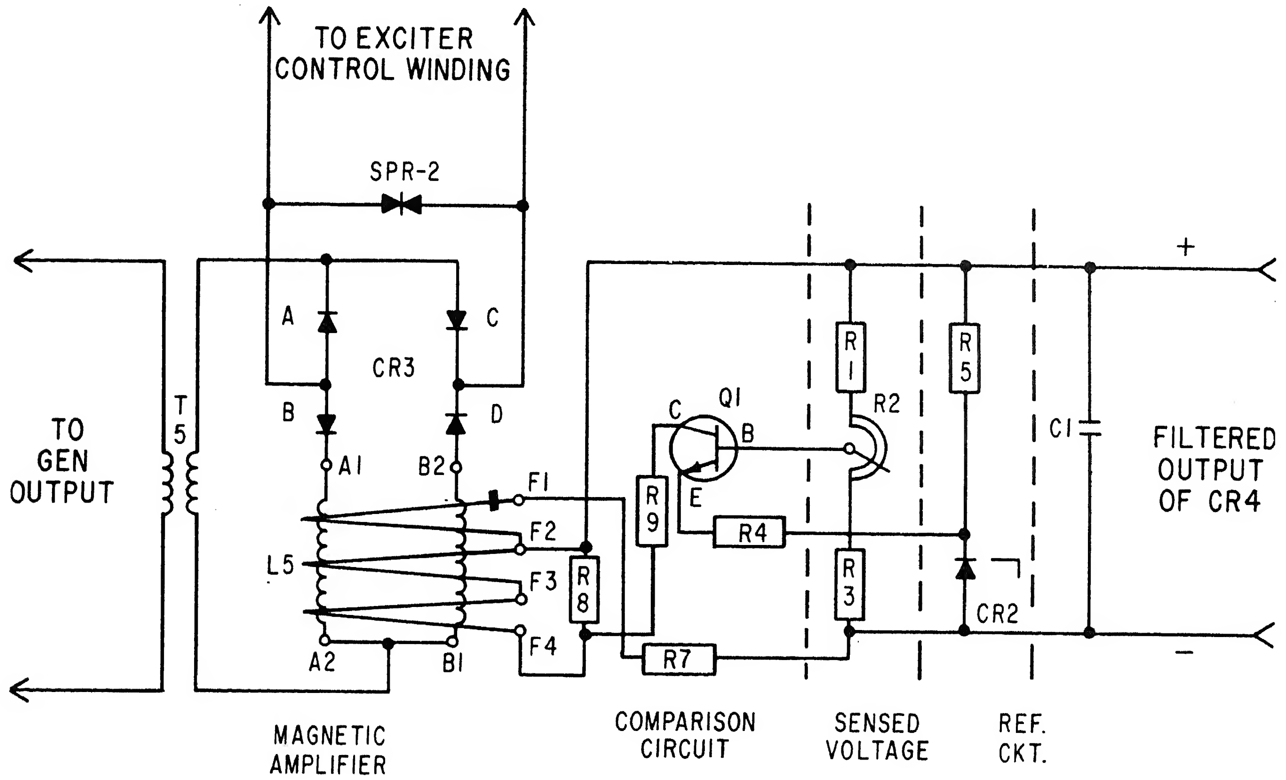
Resistors R1, R2 (automatic voltage-control resistor) and R3 form a voltage divider. The voltage between the slider of resistor R2 (sensed voltage) and the negative side of CR4 is always proportional to the output of CR4 and to the average line voltage.

This sensed voltage is applied to the base of transistor Q1 and the reference voltage is applied to the emitter. Whenever the sensed voltage is high, transistor Q1 will be biased (turned) on, causing collector to emitter current to flow through magnetic amplifier control winding F2-F4, thereby phasing the magnetic amplifier on (saturating the core) which increases the gate winding current (A1-A2; B1-B2) in the magnetic amplifier.

If the generator output voltage is low, the sensed voltage will be low, transistor Q1 will be biased (turned) off, and no control current will flow in the control winding F2-F4 of the magnetic amplifier, which will operate in an unsaturated condition. This, in turn will raise output voltage.

Voltage is adjusted by changing the position of the slider on the automatic voltage-control resistor R2. If the slider is turned toward resistor R3, a smaller portion of CR4 output voltage is compared to the reference voltage, and the regulator acts to increase the line voltage as well as the voltage at the slider until the balance is restored. The line voltage is lowered by turning the slider toward resistor R1.

MAGNETIC AMPLIFIER CIRCUIT.—Changes in the generator voltage produce changes in the current in the comparison circuit in the order of milliamperes. However, it is desirable to have these small current changes produce changes in the order of amperes in the control windings of the SCPT's. This is accomplished by using a magnetic amplifier (fig. 2-14) between the comparison circuit and the control windings of the SCPT's.

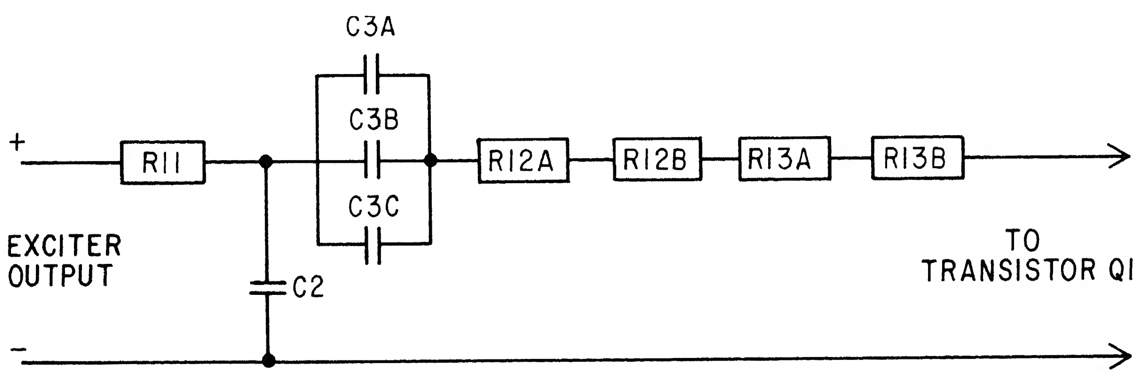


11.30

Figure 2-14.—Reference/Sensed Voltage/Comparison Circuit.

STABILIZING CIRCUIT.—In any closed-loop regulating system containing more than two significant time constants and having relatively high gain, there can be a condition of sustained oscillations, sometimes called "hunting." To prevent this condition, a stabilizing circuit has been inserted between the field of the generator or exciter output and the comparison circuit.

The elementary diagram for this stabilizing circuit is shown in fig. 2-15. Resistor R11 and



11.30

Figure 2-15.—Stabilizing circuit.

capacitor C2 form a filter to remove the normal ripple from the exciter output voltage. Resistors R12 and R13 and capacitors C3 provide optimum system stability.

Manual Voltage Control

The generator output voltage can be controlled manually by manual voltage control rheostat R20 (fig. 2-16).

Rectifier CR1 voltage (exciter output voltage) is applied to the SCPT control windings through manual control rheostat R20. An increase in R20 resistance decreases SCPT control current, which increases the exciter output voltage.

SPEED REGULATION

Speed regulation of the prime mover is needed on both a.c. and d.c. generators. As load is applied to the generators, the prime movers tend to slow, thus changing the characteristics of the generator output. Although the Navy uses many types of speed regulators, we shall discuss only the newer type which is being installed on newly constructed vessels.

ELECTROHYDRAULIC LOAD-SENSING SPEED GOVERNOR

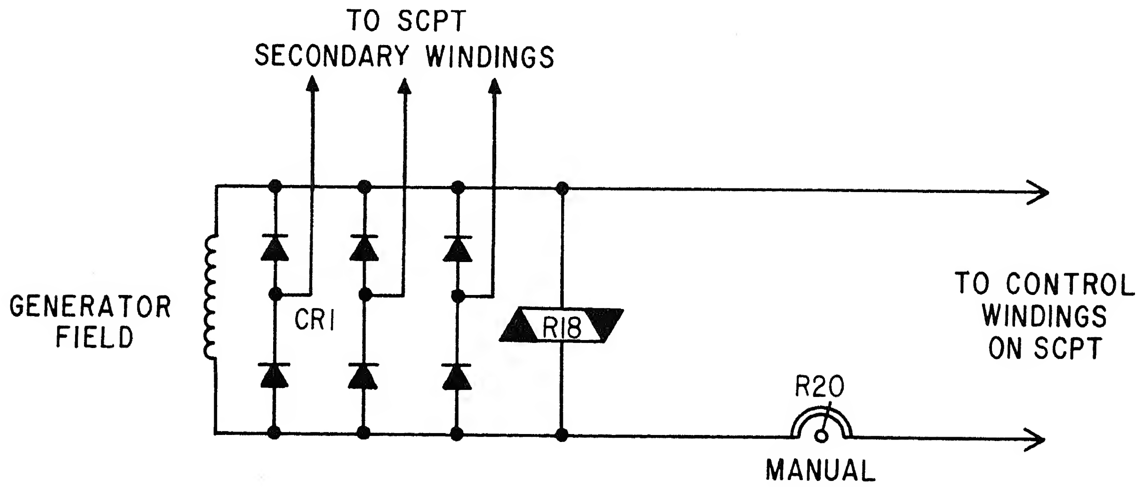
Electrohydraulic load-sensing speed governors are used with ship's service generators in electrical systems which require closer frequency regulation than that provided by mechanical type governors. Electrohydraulic governors have met with great success on both steam-turbine and diesel-driven generators.

An electrohydraulic governor may be operated as an isochronous governor (constant speed at all loads) or with speed droop which permits paralleling with other generators that have conventional fly-weight governors.

Operation

The steam valve or throttle that controls the prime mover fuel supply is operated by an electrohydraulic actuator which responds to the output of a magnetic amplifier. Generator speed and load signals are fed into the transistor amplifier to produce a power output sufficient to operate the electrohydraulic actuator which correctly positions the steam valve or throttle.

The speed signal is usually provided by a small permanent magnet generator driven from the shaft of the prime mover or ship's service generator. The speed signal is sometimes obtained by sensing the output frequency of the ship's service generator, but the loss of signal in case of short circuit on the generator is a disadvantage of this method. The speed signal is applied to a frequency sensitive circuit and to a reference circuit in the governor control unit. The output of this circuit is an error



11.30

Figure 2-16.—Manual voltage control circuit.

signal if there is any deviation from rated speed. The error signal is applied to the transistor amplifier and acts to restore rated speed. Stability is obtained by the use of electrical feedback circuits.

Load-measuring circuits are used in the electrohydraulic governor to obtain proper load ratio on each paralleled generator. Most governing systems are so designed that any change in load produces a signal which is fed into the transistor amplifier and acts to offset any anticipated speed change due to load change. The load-measuring circuits on governors of all generators that operate in parallel are connected by a tie cable. The governor may be designed or preset so that each paralleled generator will equally share the total load, or a load ratio adjustment may be provided. Any deviation in proper load ratio produces a circulating current in the tie cable. The circulating current acts in the transistor amplifier circuit to increase or decrease fuel supplied to the generator prime movers until proper load ratio is achieved.

The electrohydraulic load-sensing governor used in this discussion is made up of four major units (fig. 2-17) — the EG-M control box, the load signal box, the EG-R hydraulic actuator, and the valve operator.

The input signal (voltage) is proportional to the speed of the permanent magnet generator (PMG) and is applied to the EG-M control box (fig. 2-18). The control box compares this voltage with a reference voltage and, if there is a difference, supplies an output voltage to energize the EG-R hydraulic actuator. A pilot valve plunger in the actuator directs oil to or from a remote servo in the valve operator. The valve operator moves the mechanism to increase or decrease the steam, which returns the turbine speed to normal.

The load signal box detects changes in load before they appear as speed changes and applies a proportional voltage to the EG-M control box. The load signal box detects these changes through the resistor box, which develops a voltage from the secondary of current transformers. This voltage is compared with the generator load output voltage and, if a difference exists, the load signal box applies a proportional voltage to the control box.

The droop switch allows parallel operation with governors of types other than EG. The circuit breaker auxiliary contact provides a path for control load signals to other paralleled units.

NO-BREAK POWER SUPPLY SYSTEM

A no-break power supply system provides an uninterrupted electrical power supply which is relatively constant in voltage and frequency under all load conditions. The no-break power supply automatically takes over when the normal power supply is interrupted, off-frequency, or off-voltage. The no-break power supply system is presently being used by ships using the Central Operations Systems and by ships with equipment, control, or computer systems which need an uninterrupted electrical power supply for effective operation.

The system uses a motor-generator set, batteries, and associated controls to provide its regulated output. Either unit of the motor-generator set can perform as a motor with the other as generator, thus permitting two modes of operation.

MOTOR GENERATOR MODE 1

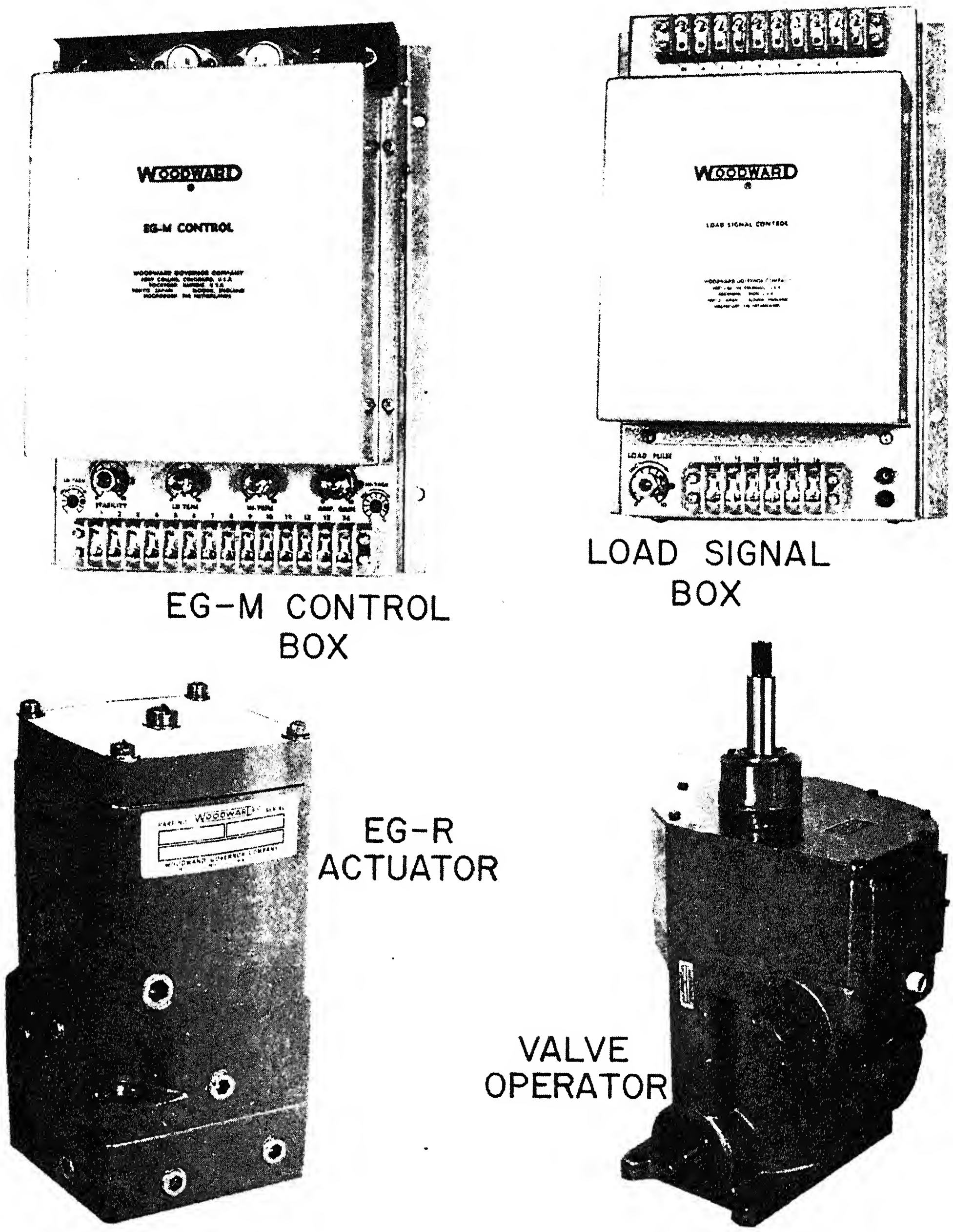
In mode 1 operation of the motor-generator set (fig. 2-19A), the a.c. end of the set is driven from the ship's service power supply; the d.c. end is a generator providing power to the system batteries. This mode of the motor-generator operation exists when the ship's service power supply is meeting the voltage and frequency requirements of the critical load.

MOTOR-GENERATOR MODE 2

Mode 2 operation of the motor-generator set (fig. 2-19B) represents the condition by which the set receives power from the batteries, and the a.c. end of the set provides the power requirements for the critical load. Mode 2 is referred to as the Stop Gap Operation.

STATIC POWER SUPPLIES

Static power supplies using solid-state components are being used for many shipboard

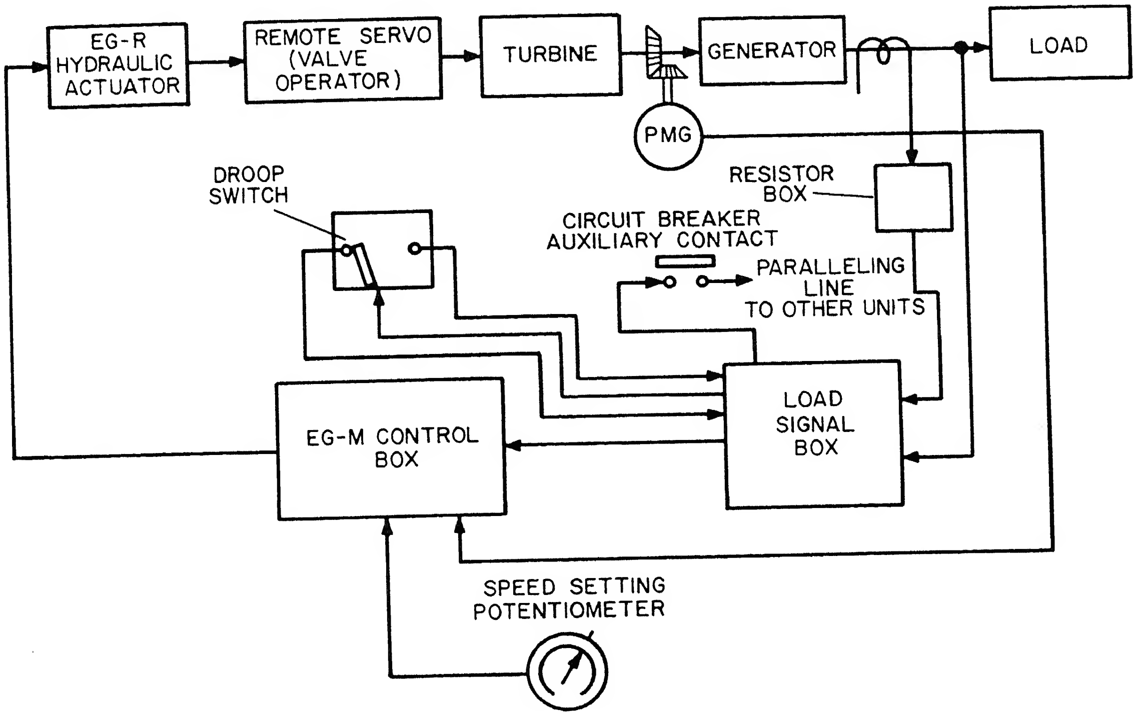


111.150X
Figure 2-17.—Electrohydraulic load-sensing governor system components.

applications, specifically, 400-Hz equipment. We have already described an MG set which converts 60-Hz to 400-Hz. Static power supplies offer certain advantages over MG sets, such as lighter weight, smaller space requirements, and no moving parts, hence quieter operation, less maintenance, higher efficiency, and faster reaction time to transient disturbances. Static power supplies can be designed to change d.c. to a.c., a.c. to d.c., or a.c. to a.c. of different frequencies.

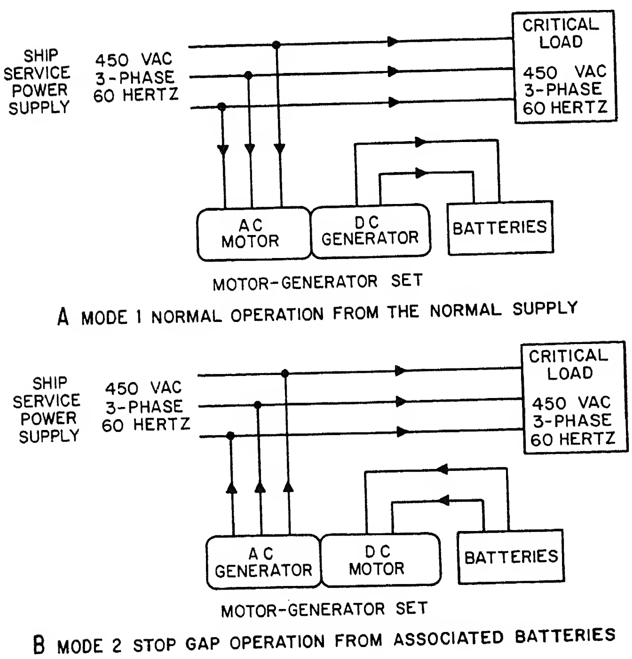
5 kW 250 VDC, 120
VAC 400 Hz STATIC
INVERTER

The model 4345D Static Inverter (fig. 2-20) develops a closely regulated source of 400-Hz,



111.151

Figure 2-18.—Block diagram of the electrohydraulic load-sensing governor system.

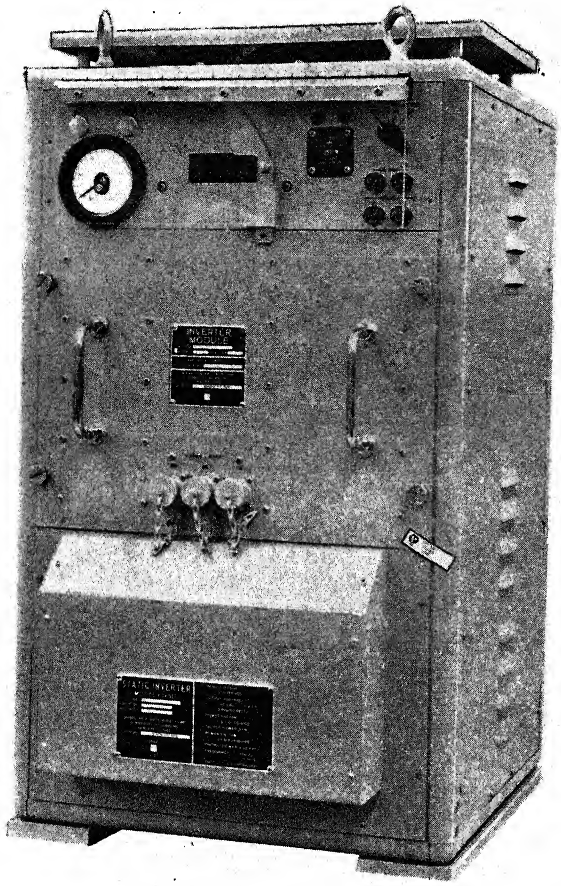


77.297

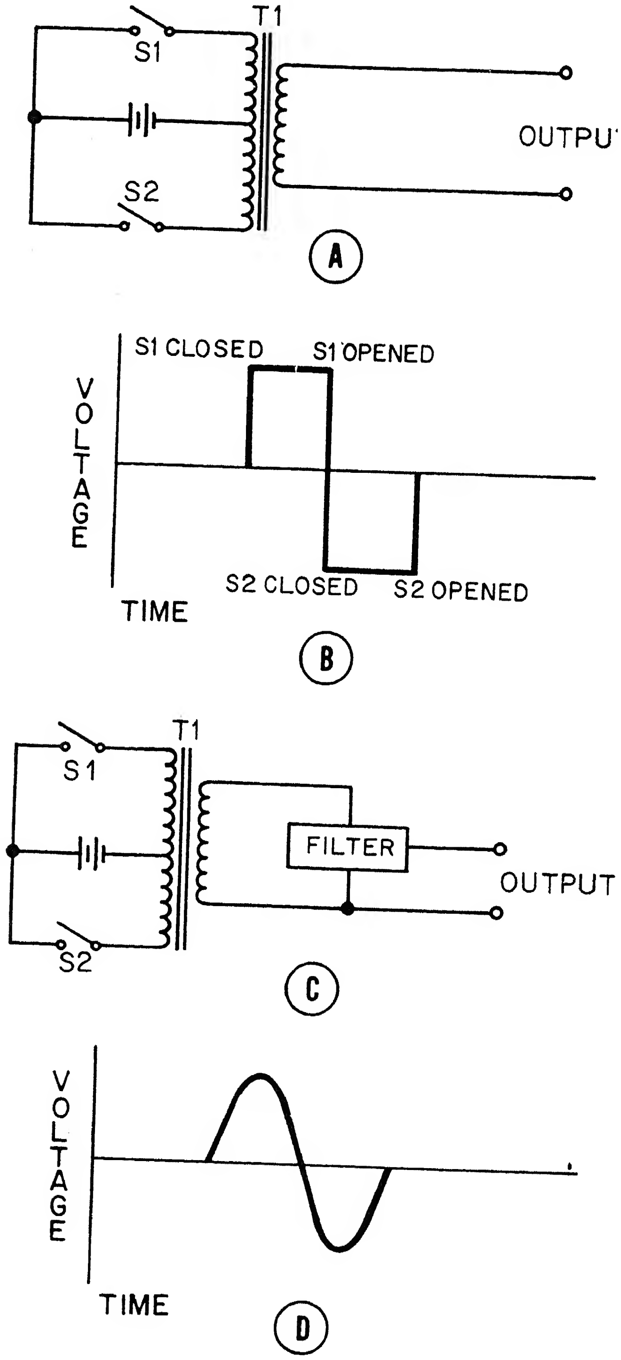
Figure 2-19.—Block diagram of the no-break power supply.

3-phase power from a 240 VDC source. We shall not attempt to cover the circuitry of this system in our discussion. One basic circuit will be used as an example of how the theory is possible.

Basically, d.c. power is converted to a.c. power in the inverter sections by a rapid change in the direction of current flow through a transformer. In figure 2-21A the main d.c. source is placed across the primary of a transformer. If switch S1 is closed, a voltage is produced on the secondary of transformer T1. When S1 is reopened, the voltage decreases to zero. A similar action occurs if S2 is closed and reopened, but the voltage produced is of opposite polarity. Referring to figure 2-21B a square wave form would be produced. By timing the switching action and adding a filter (fig. 2-21C) to the secondary of T1 you can obtain a 400-Hz sine wave (fig. 2-21D). In the inverter, S1 and S2 are replaced by semiconductor devices. There are two inverters which operate 90° out of phase to produce a standard two-phase power. The 2-phase, sine-wave power is then converted to 3-phase power by a SCOTT T-connected Transformer. Detailed functions and test points should



40.79X
Figure 2-20.—Static inverter.

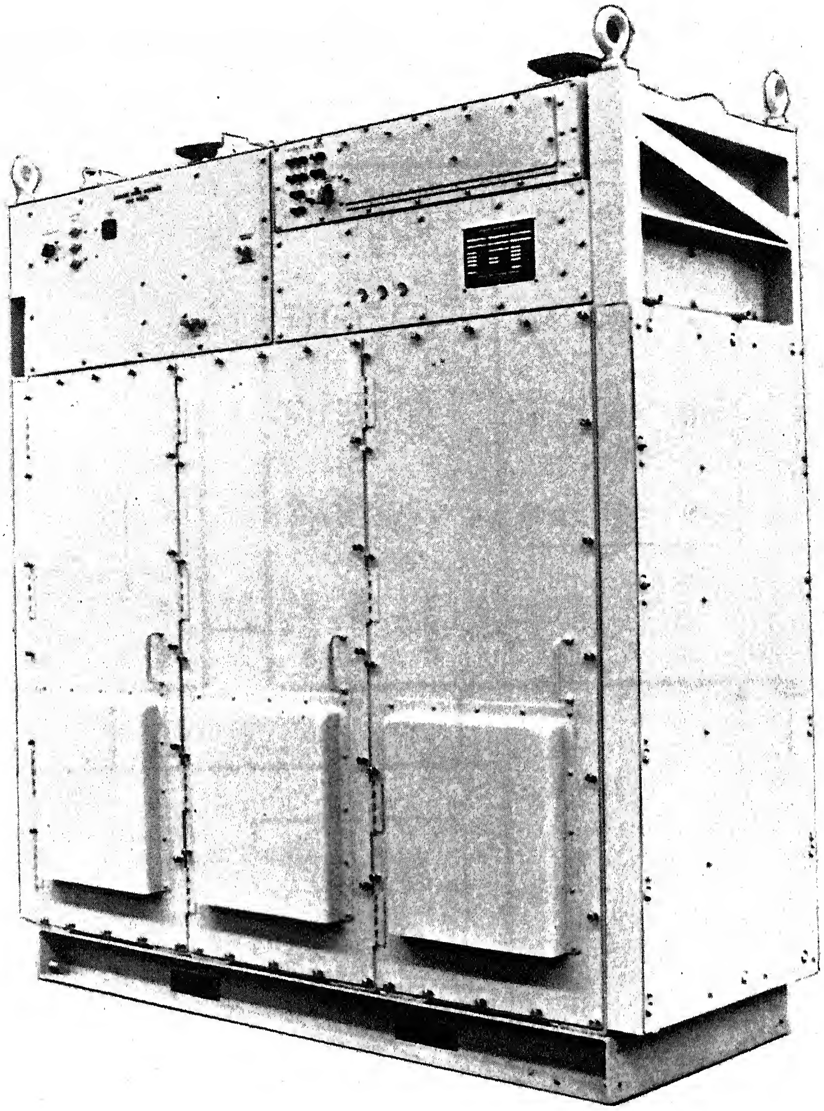


27.316
Figure 2-21.—Basic inverter.

be obtained from the manufacturers technical manual.

150 kW 440 VAC 60-Hz,
450 VAC 400-Hz STATIC
CONVERTER

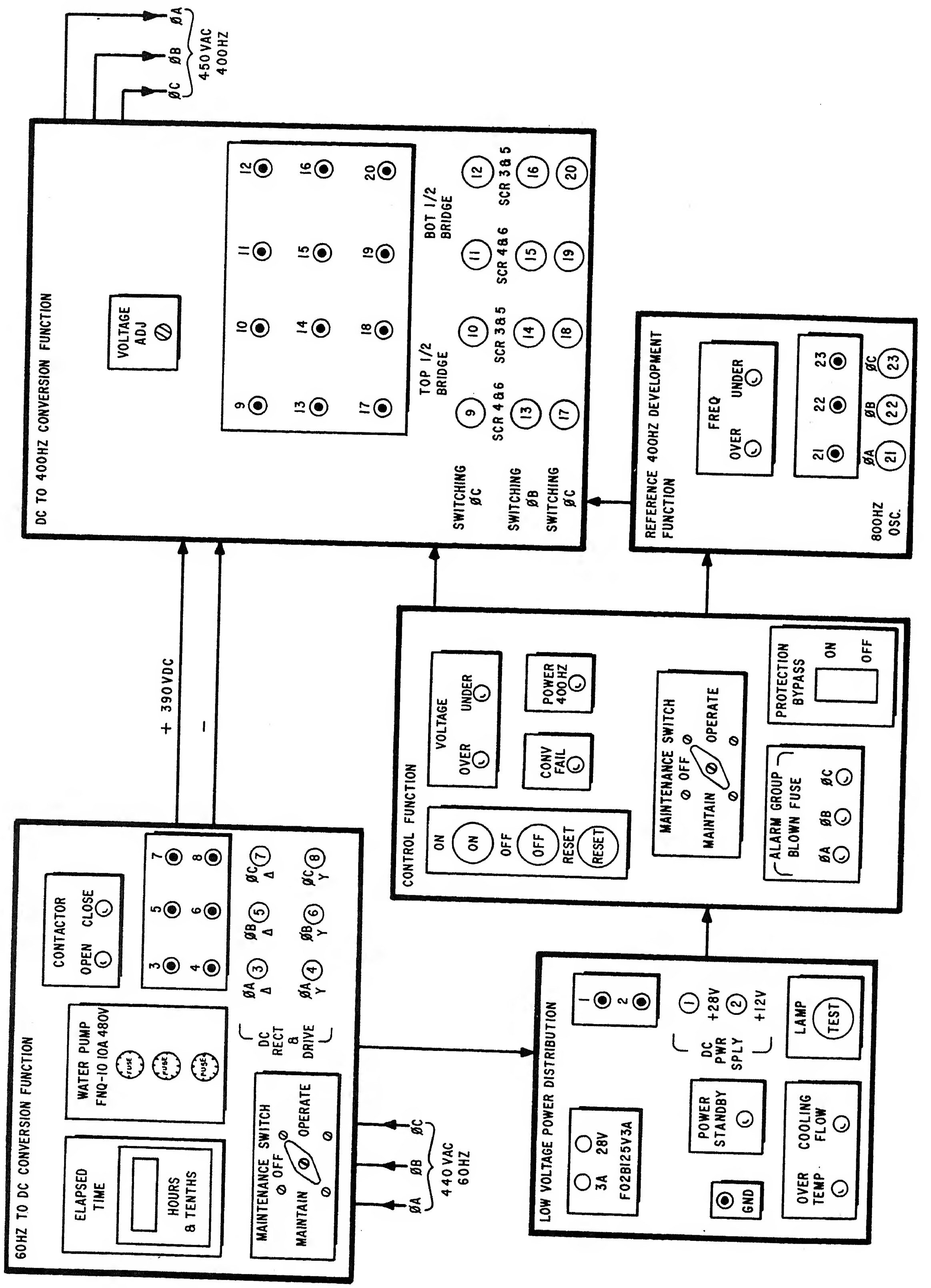
Some newer ships are using a centralized 400-Hz power supply to meet the ever-increasing 400-Hz equipment demands. The newer DD's use a static power converter that produces an output of 450 VAC, 400 Hz, 3 phase at a maximum of 150 kW continuous power. An input of 440 VAC, 60-Hz, 3 phase is required (fig. 2-22).



27.315X

Figure 2-22.—Power converter assembly.

The 150 kW converter works basically the same as the 5 kW model 4345D inverter, first changing the a.c. to d.c., then using the same basic switching action as the 5 kW inverter. Note in figure 2-23 that the 440 VAC 60 Hz goes into the 60 Hz to DC CONVERSION FUNCTION. This section converts the a.c. to approximately 390 VDC. The LOW VOLTAGE POWER DISTRIBUTION section provides low voltage power from the 440 VAC input to operate transistors, logic circuits, and other integrated circuits in the rest of the converter. The CONTROL FUNCTION provides signals that control the operation of the converter. Signals from other functions are processed to provide output voltage control signals and, in the event of faults,



27.315

Figure 2-23.—Simplified block diagram of a power converter.

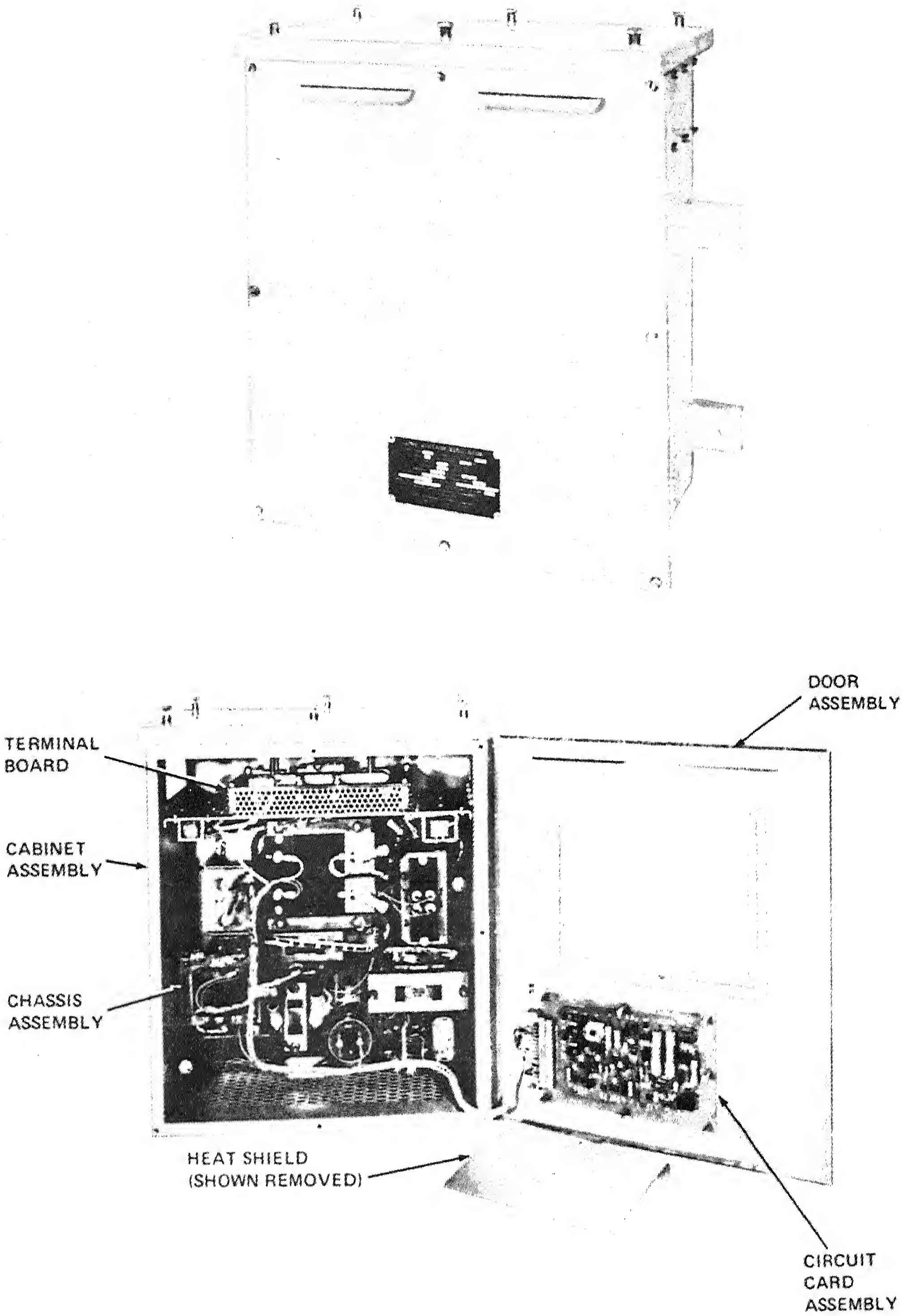


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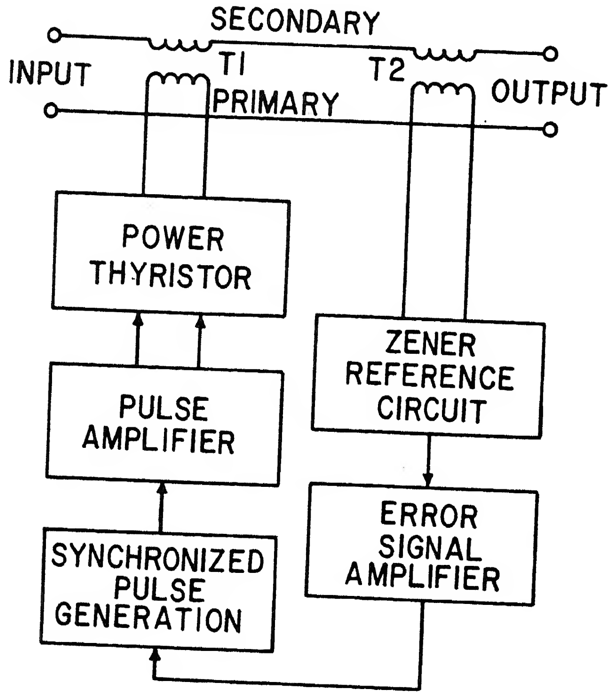
Figure 2-24.—Line voltage regulator type 1ES25007 front views open and closed.



111.102
Figure 2-25.—Line voltage regulator simplified block diagram.

to provide signals that automatically shut down the converter. The REFERENCE 400-HZ DEVELOPMENT FUNCTION generates signals to drive the DC 400-HZ CONVERSION FUNCTION circuits. These signals are developed by a 4800-Hz oscillator (pulse generator) whose frequency is controlled by a d.c. input. The DC TO 400-HZ CONVERSION FUNCTION contains the switching devices necessary to convert the d.c. to 400 Hz a.c. The frequency output is controlled by signals from the REFERENCE 400-HZ DEVELOPMENT FUNCTION, and the voltage output is controlled by signals from the CONTROL FUNCTION. Because of the relatively high power output, a heat exchanger is incorporated to provide cooling to the inductors, transformers, and rectifiers for each of the three phases. A continuous flow of seawater cools a closed fresh water system. The fresh water is circulated by a pump through the heat exchanger.

LINE VOLTAGE REGULATORS

Line voltage regulators are used on naval ships for equipment that requires closely regulated voltage under varying load conditions.

There are several designs of line voltage regulators available. The basic operation described in the next section will cover a typical design.

TYPE 1ES25007 LINE VOLTAGE REGULATOR

The type 1ES25007 line voltage regulator (fig. 2-24) will maintain 114 V, 75 amp, 87 kVA at ± 0.5%. Regulation is achieved by controlling a transformer directly in line with the load. The operation is designed around Thyristors, which control the primary of T-1. Thyristors are transistors which have a switching characteristic.

A line voltage is sensed at transformer T-2 (fig. 2-25) and compared with a zener diode network. Any error is then amplified and sent to the synchronized pulse generator which is designed to keep the error signal in phase with line voltage. The error signal then goes through a pulse amplifier which fires (switches) the Thyristors to either aid or buck the voltage at Transformer T-1. If sensed line voltage is suddenly increased, a buck signal is applied to T-1, tending to oppose this increase. If a reduction in line voltage occurs, an opposite action will take place.

CHAPTER 3

DISTRIBUTION SYSTEMS

Chapter 2 dealt with different methods of enerating voltage using various types of equip- ent. In this chapter we shall discuss how this ower (generated voltage) is distributed on naval essels and how selective tripping is utilized. e shall also discuss the devices used to accom- lish power distribution in a safe, reliable nd efficient manner.

The a.c. power distribution system aboard ip consists of the a.c. power plant, the means distribute the power, and the equipment which nsumes the power, such as lighting systems nd electric motors. The power plant is either e ship's service electric plant or the emergency lectric plant. The means of distributing the ip's service power is through load centers nd power panels.

SHIP'S SERVICE POWER DISTRIBUTION

Most a.c. power distribution systems in naval essels are 450-volt, 3-phase, 60-hertz, 3-wire, grounded systems.

The ship's service generator and distribution witchboards (fig. 3-1) are interconnected by s ties so that any switchboard can be connected feed power from its generators to one or ore of the other switchboards. The bus ties lso connect two or more switchboards so that e generator plants can be operated in parallel. he power distribution to loads can be from e generator and distribution switchboards or om switchgear groups to load centers, to istribution panels, and to the loads, or directly om the load centers to larger loads.

EMERGENCY POWER DISTRIBUTION

The emergency power distribution system pplies an immediate and automatic source of electric power to a limited number of selected vital loads in the event of failure of the ship's service distribution system. This system, which is separate and distinct from the ship's service distribution system, includes one or more emer- gency distribution generators and switchboards. Each emergency switchboard (fig. 3-2) is supplied by its associated emergency generator. The emergency feeders run from the emergency switchboards and terminate in manual or auto- matic bus transfer equipment at the distribution panels or at loads for which emergency power is required. The emergency power distribution sys- tem is 450-volts, 3-phase, 60-hertz with trans- former banks at the emergency distribution switchboards to provide 120-volt, 3-phase power for the emergency lighting system.

The emergency generators and switchboards are located separately from the ship's service generators and distribution switchboards. The emergency feeders are located near the center- line and higher in the ship (above the waterline) than the normal and alternate ship's service feeders. This arrangement provides horizontal separation between the normal and alternate ship's service feeders and vertical separation between these feeders and the emergency feeders, thereby minimizing the possibility of damaging all three types of feeders simultaneously.

The emergency switchboard is connected by feeders to at least one and usually to two different ship's service switchboards (fig. 3-3). One of these ship's service switchboards is the normal source of ship's service power for the emergency switchboard and the other is the alternate source. The emergency switchboard and distribution system is normally energized from the normal, or preferred source of ship's service power. If this source of power should fail, bus transfer equipment automatically transfers the emergency switchboard to the alternate source of the ship's service power. If both the normal

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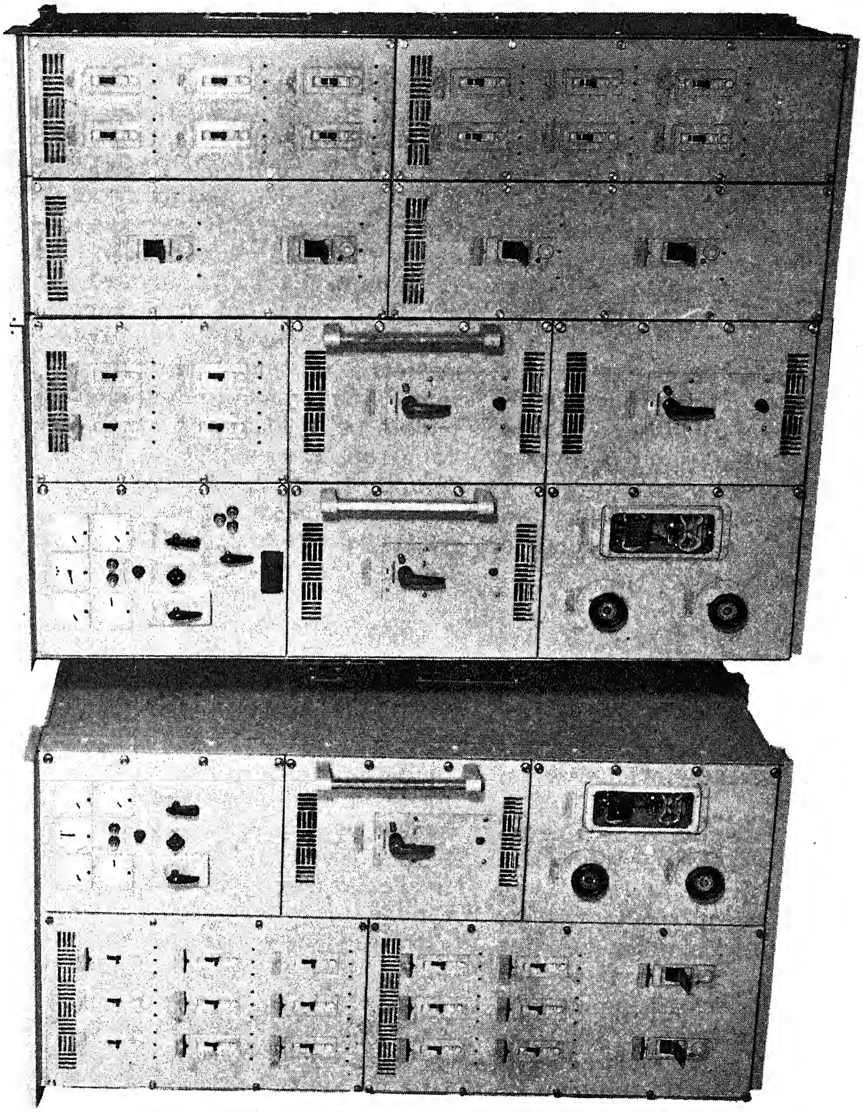

Figure 3-1. —Ship's service switchboard.

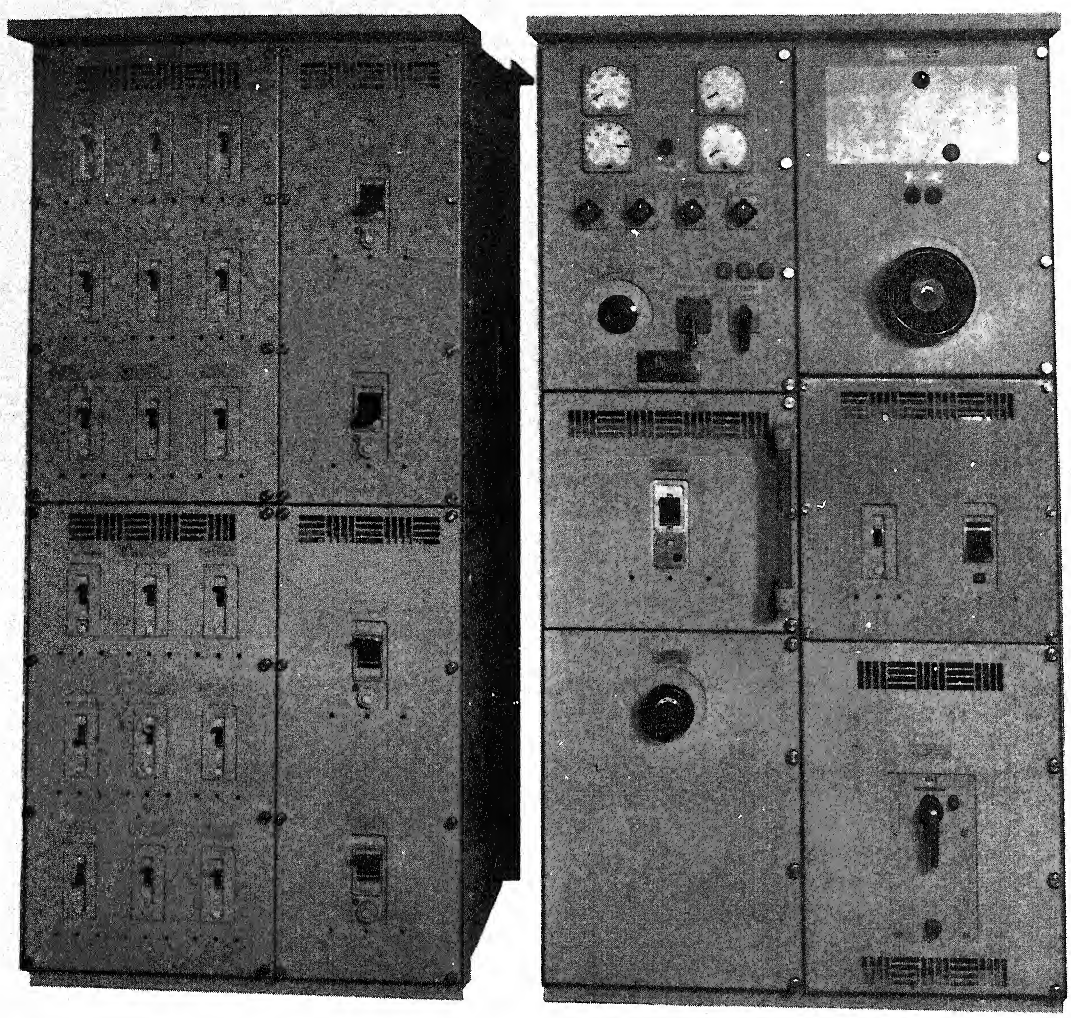

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Figure 3-2.—Emergency switchboard.

and alternate source of ship's service power fails, the emergency generator will start automatically within 10 seconds after power failure and the emergency switchboard will automatically transfer to the emergency generator.

CASUALTY POWER DISTRIBUTION SYSTEM

Damage to ship's service and emergency distribution systems during wartime led to the development of the casualty power system. The casualty power distribution system provides for making temporary connections (runs) to vital circuits and equipment (fig. 3-4). The system is limited to only those facilities necessary to keep the ship afloat and to permit the ship to get out of the danger area. The system also supplies a limited amount of power to armament, such as antiaircraft guns and their directors to protect the ship when in a damaged condition.

Optimum continuity of service is ensured in ships provided with ship's service, emergency,

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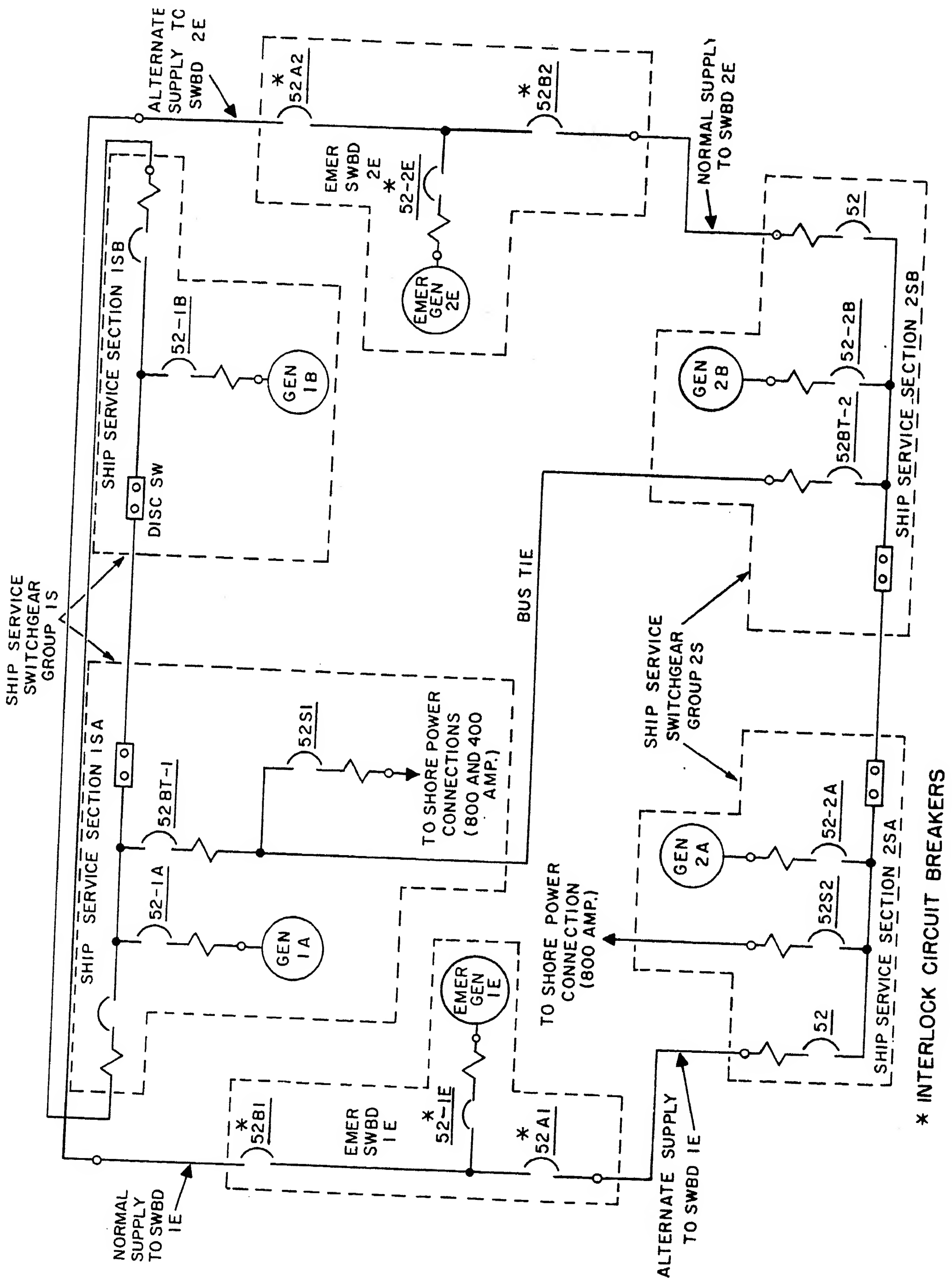

Figure 3-3.—Power distribution (60 hertz) system on a DLG.

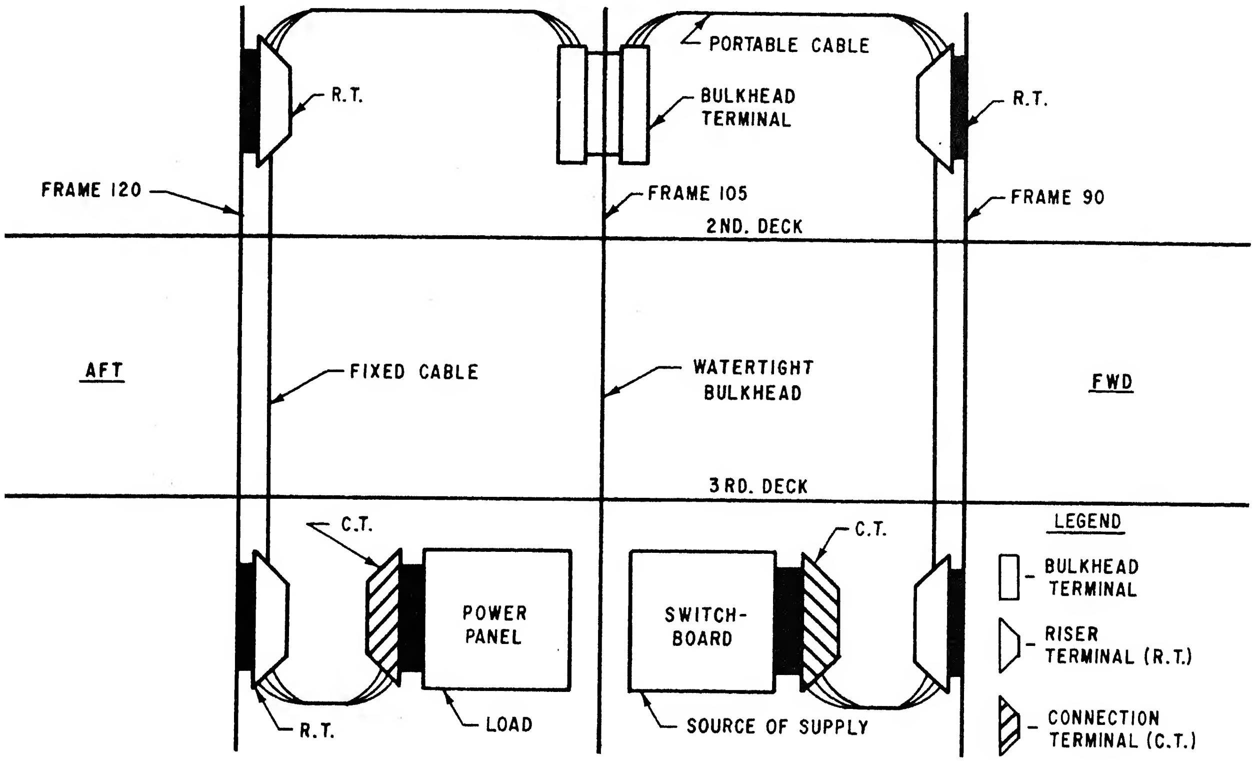

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Figure 3-4. — Typical power run.

l casualty power distribution systems. If one ıerating plant fails, a remote switchboard ı be connected by the bus tie to supply power m the generator or generators that have not ؛ed.

If a circuit or switchboard fails, the vital ds can be transferred to an alternate feeder . source of ship's service power by means of a nsfer switch near the load.

If both the normal and alternate sources of ship's power fail because of a casualty to ;enerator, switchboard, or feeder, the vital iliaries can be shifted to an emergency feeder t receives power from the emergency switch-rd.

If the ship's service and emergency circuits , temporary circuits can be rigged with the ualty power distribution system and can be d to supply power to vital auxiliaries if any the ship's service or emergency generators be operated.

The casualty power system includes suitable lengths of portable cable stowed on racks throughout the ship. Permanently installed casualty power bulkhead terminals form an important part of the casualty power system. They are used to connect the portable cables on opposite sides of bulkheads, so that power may be transmitted through compartments without loss of watertight integrity; also included are permanently installed riser terminals between decks (fig. 3-5A). The vital equipment selected to receive casualty power will have a terminal box (mounted on or near the equipment or panel concerned) connected in parallel with the normal feeder for the equipment.

Sources of supply for the casualty power system are provided at each ship's service switchboard and emergency generator switchboard (fig. 3-5B). A casualty power terminal is installed on the back of the switchboard, or switchgear group, and connected to the bus ties through a 225- or 250-ampere AQB circuit

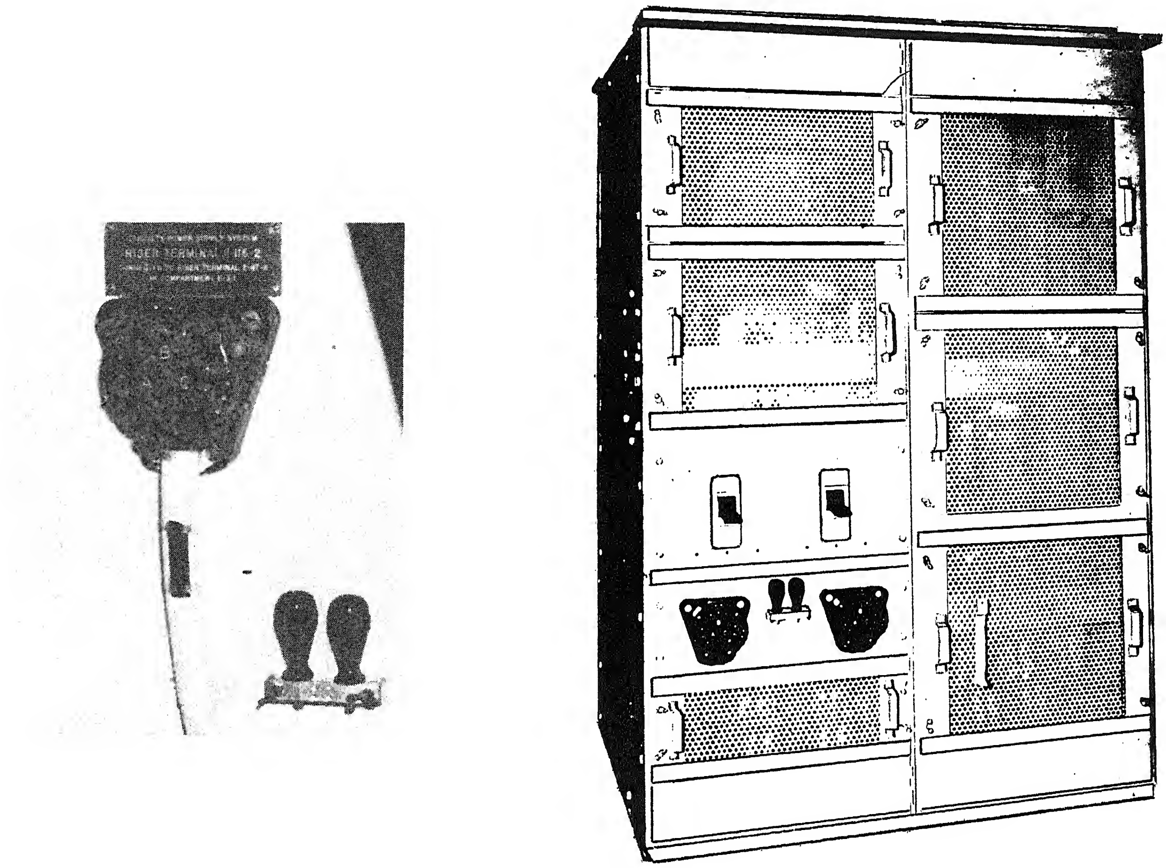

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Figure 3-5.— Casualty power terminals.

breaker. This circuit breaker is connected between the generator circuit breaker and the generator disconnect links so, that by pulling the disconnect links, the generator may be isolated from the switchboard and may be used exclusively for casualty power purposes, if desired.

Due to the inherent dangers of electric shock involved with the rigging of casualty power cables, you, as division officer or electrical officer, should be thoroughly familiar with NavShips Technical Manual Chapter 9880 Section III, Engineering Damage Control, and the casualty control manual for your ship.

SWITCHBOARDS

The a.c. switchboards may consist of a single section or of several sections physically separated and connected by cables to form a switchgear group. This arrangement of sections provides greater resistance to damage caused by shock and also provides a means to localize damage and to remove damaged sections for repairs or replacement.

The ship's service switchboard (fig. 3-6) is housed in sheet-steel panels or enclosures from which only the meters and operating handles of the switches and circuit breakers protrude to the front of the switchboard. This type of construction is used for all a.c. distribution systems and for the d.c. distribution systems in some large ships. (Compare the ship's service switchboards shown in figures 3-1 and 3-6. Although there is a variety of designs for these switchboards depending on the needs of the ship, the switchboards basically function in the same manner.)

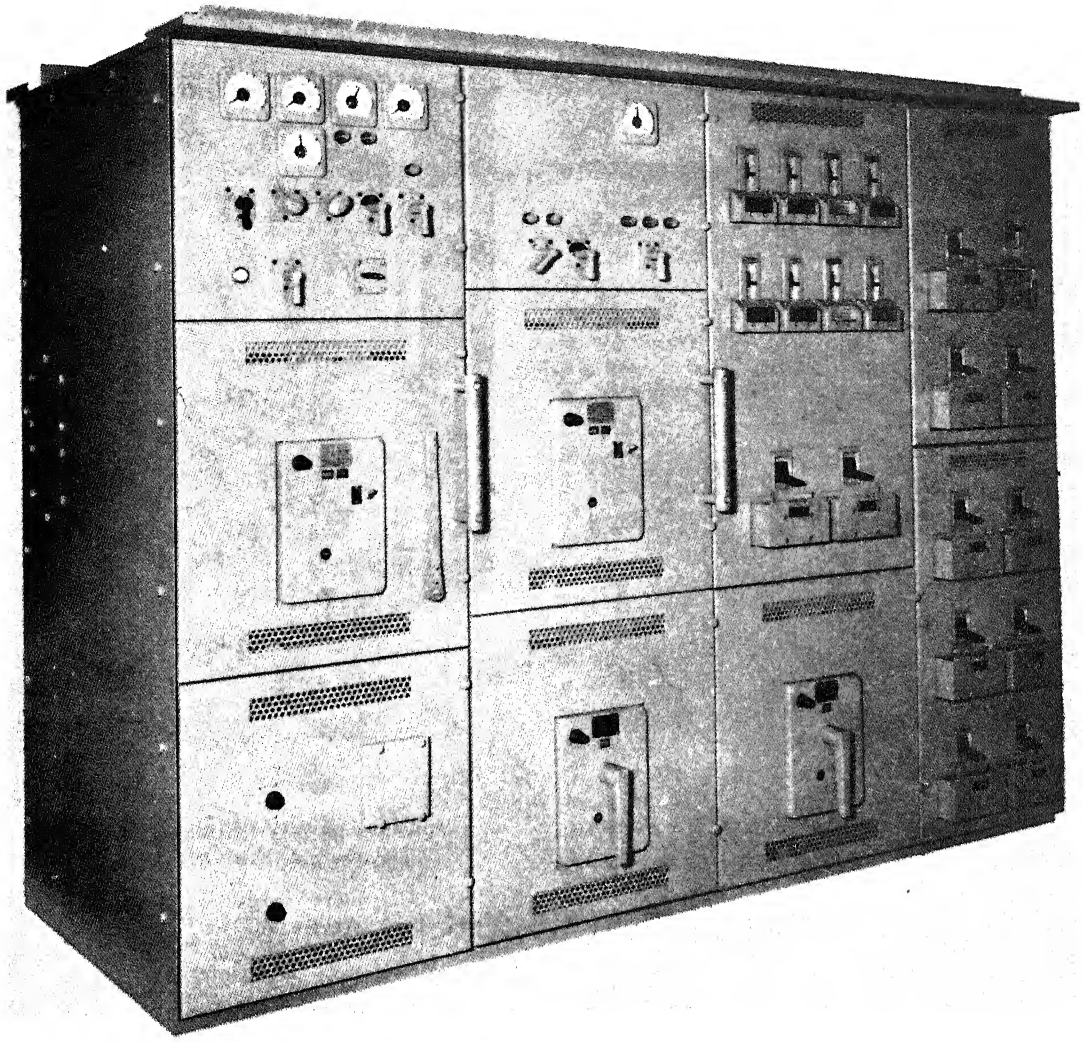

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Figure 3-6.—Ship's service switchboard.

The switchboard equipment is grouped to form a number of units, each unit complete with a separate front panel and all the required devices such as controls on the a.c. generator control unit. In addition, there is an a.c. bus tie unit, a power distribution unit, and a lighting distribution unit. A number of units mounted on a common base comprise a section or several sections which may be physically separated and connected by cables to form a switchgear group.

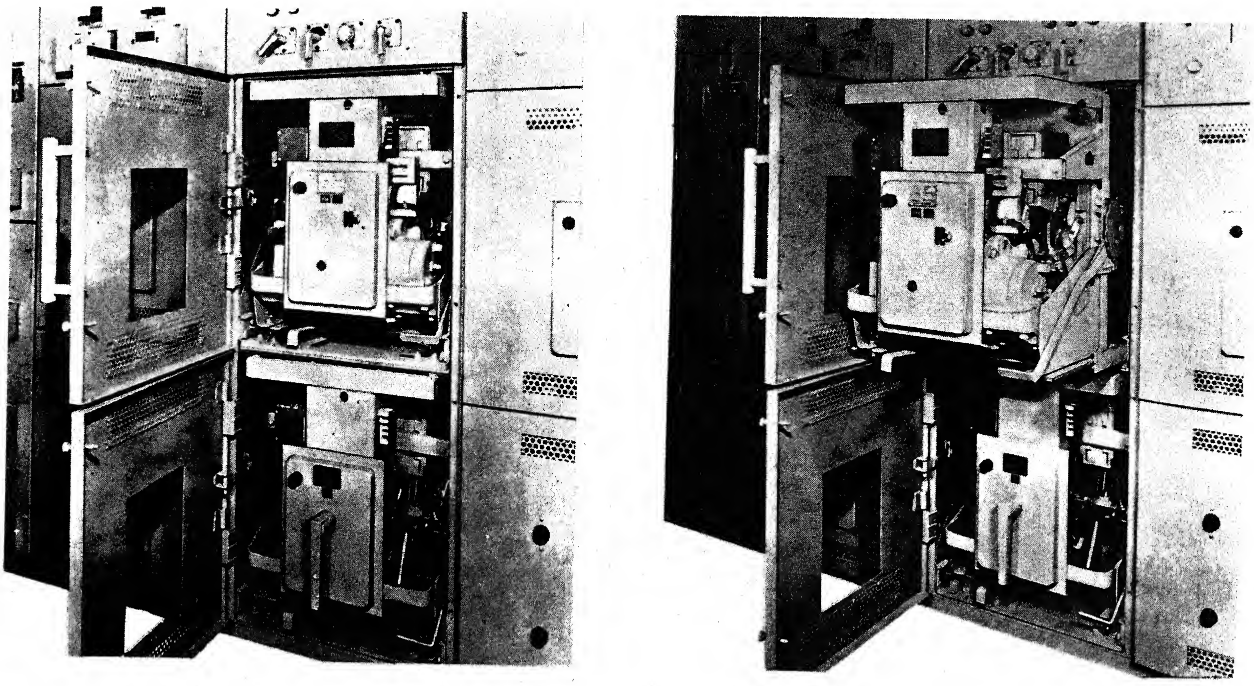
CIRCUIT BREAKERS

Circuit breakers have three fundamental purposes: they provide circuit protection; they perform normal switching operations; and they isolate a defective circuit while repairs are being made.

Air circuit breakers are used in switchboards, switch gear groups, and distribution panels. The types, labeled according to size, on naval ships are ACB, AQB, AQB-A, AQB-LF, NQB-A, ALB and NLB. They are called air circuit breakers because the main current-carrying contacts interrupt in air.

Circuit breakers can be manually or electrically operated. Some types may be operated both ways, while others are restricted to one mode.

Some larger circuit breakers have a drawout feature (fig. 3-7) which allows the electrician's



A

IN NORMAL POSITION

B

IN WITHDRAWN POSITION

77.258(.259)

Figure 3-7.—Large circuit breaker (ACB-1600).

mate to perform maintenance, tests and inspections with greater ease. Smaller breakers (fig. 3-8) can be removed from the switchboard by loosening the mounting screws and pulling the breaker from the board.

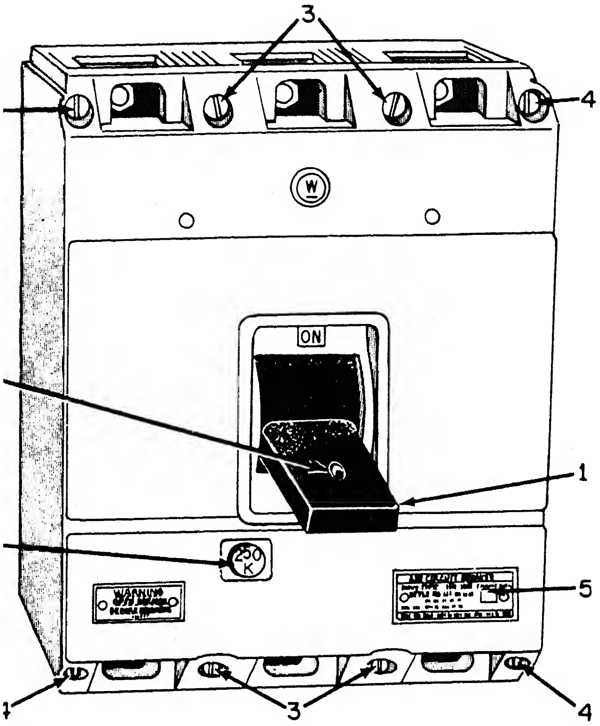
An explanation of different circuit breakers will not be complete without including a brief description of selective tripping features and their uses.

Selective Tripping

Selective tripping of circuit breakers permits isolation of a faulty section of the system and, at the same time, maintains power to as much of the system as possible. Selective tripping (coordination of the time-current characteristic of circuit breakers) is normally obtained by a mechanical, short time-delay feature of the circuit breakers so that the breaker closest to the fault will open first, and the breaker farthest from the fault and closest to the generator will open last.

The short time-delay feature can be varied with limitations. The generator circuit breaker, which is closest to the power source, has the maximum continuous current-carrying rating, the highest available short-circuit current rating, and the maximum short time-delay trip to ensure that the generator breaker will be the last breaker to trip. However, the generator breaker will trip, within the tolerance of the breaker, on the generator short circuit current at some definite interval of time.

A portion of a distribution system with circuit breakers employing selective tripping is illustrated in figure 3-9. The so-called instantaneous tripping time is the minimum time required for a breaker to open and clear a circuit when the operation of the breaker is not intentionally



OPERATING HANDLE SHOWN IN LATCHED POSITION
AMPERE RATING MARKER
MOUNTING SCREWS
4. COVER SCREWS
5. BREAKER NAMEPLATE
6. COTTER KEY HOLE

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'igure 3-8.—Complete front view of an AQB-A250 circuit breaker.

elayed. Each circuit breaker will trip in less ıan 0.1 second (almost instantaneously) when ıe current exceeds the instantaneous trip current etting of the breaker. In a shipboard selective :ipping power system the individual circuit reakers (generator, bus tie, shore power or ;eder breakers) differ from each other depending n:

1. The available load current
2. The available short circuit current
3. The tripping time band and trip current settings selected

Bus tie circuit breakers are usually set to :ip after a prescribed time delay (less than ıe generator circuit breaker time delay), at a urrent that is nearest to, but not less than 50% of the bus tie breaker coil rating (for multigenerator switchgear groups) or at a current nearest to, but not more than 80% of the generator breaker short time-delay setting (for single generator switchgear groups). Instantaneous tripping is not normally used on bus tie circuit breakers.

For currents less than the instantaneous trip current setting, the circuit breakers for selective tripping are constructed to cause an intentional delay in the operation of the breaker. The time delay is greater for small currents than for large currents and is therefore known as an inverse time delay. The current that will trip the AQB load circuit breaker instantaneously and clear the circuit will not trip the ACB feeder circuit breaker unless the current flows for a greater length of time. The same sequence of operation occurs for the other groups of circuit breakers in the system which are adjusted for selective tripping. The difference between the tripping times of the breakers is sufficient to permit each breaker to trip and clear the circuit before the next breaker starts to operate.

Assume that a fault or defect develops in the cable insulation at point A (fig. 3-9) and allows an overcurrent to flow through the AQB load circuit breaker and the ACB feeder circuit breaker. The AQB load breaker will open the circuit and interrupt the current in an interval of time that is less than the time required to open the ACB feeder circuit breaker. Thus, the ACB feeder breaker will remain closed when the AQB breaker clears the circuit. However, if the fault current should exceed the interrupting capacity of the AQB load breaker (for example, an excess of 10,000 amperes), this breaker would be unable to interrupt the fault current without damage to the breaker. To prevent damage to the AQB load breaker, the ACB feeder breaker (on switchboard 1S) serves as a BACK UP breaker for the AQB load breaker and will open almost instantaneously.

A fault at point B with overcurrent would trip the ACB feeder breaker in time but not the ACB generator breakers or bus tie breakers, which require longer time intervals in which to trip. A fault at point C with overcurrent would trip both ACB bus tie breakers. A fault at D with overcurrent on switchboard 1S would trip the associated ACB generator breakers. In each case, the faulty section of the system is isolated, but power is maintained to as much of the system as possible with respect to the location of the fault.

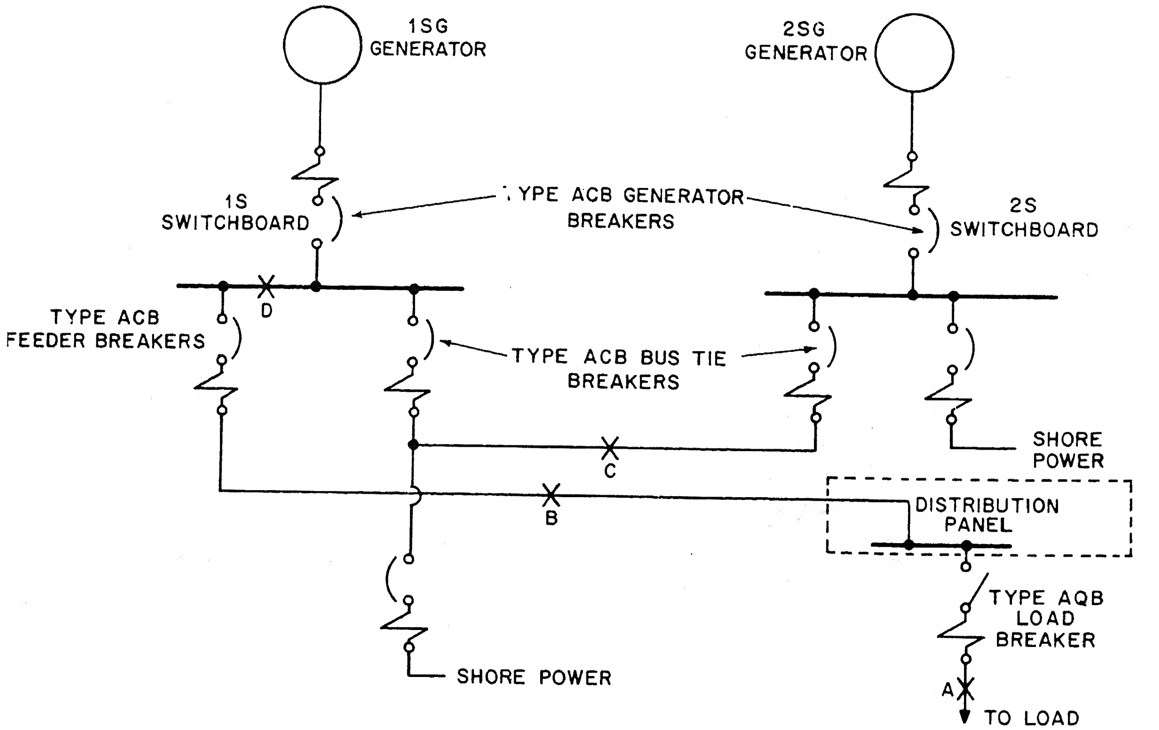

Figure 3-9.—Selective tripping of circuit breakers.

The attainment of selective tripping requires careful coordination of time-current characteristics for the different groups of circuit breakers. For example, if the system illustrated in figure 3-9 is operating split plant (bus ties open) and if the time-current characteristics of the ACB feeder breaker and the ACB generator breaker were interchanged, a fault at B with overcurrent would trip generator 1SG off the line but would leave the feeder connected to the switchboard. This action would disconnect power to all equipment supplied by switchboard 1S and also would not isolate the faulty section. Therefore, NO UNAUTHORIZED CHANGES should be made to circuit breaker trip settings because these changes may completely disrupt the scheme of protection based on selective tripping.

A circuit breaker should NEVER be removed from a switchboard without prior approval of the electrical or engineer officer, and then only after a thorough review of the applicable technical manual, and Chapter 9600 of NavShips Technical Manual.

You should NEVER work on any circuit breaker, regardless of type, until you ensure that the circuit is open. Remember that cert terminals may have voltage applied to them e though the breaker is open. Aboard ship, pow may be supplied to either end of the circ breaker.

BUS BARS

Bus bars (fig. 3-10) are heavy, rugged metal conductors usually insulated with a nonconduct paint and are used to carry the large genera loads within the switchboards.

DISCONNECT LINKS

Disconnect links (fig. 3-11) are devices us in switchboards to isolate a generator, a switc board section or a bus tie whenever equipme has been damaged or whenever maintenance required.

Disconnect links are connected in the lar bus bars and are designed to carry the enti current of the bus.

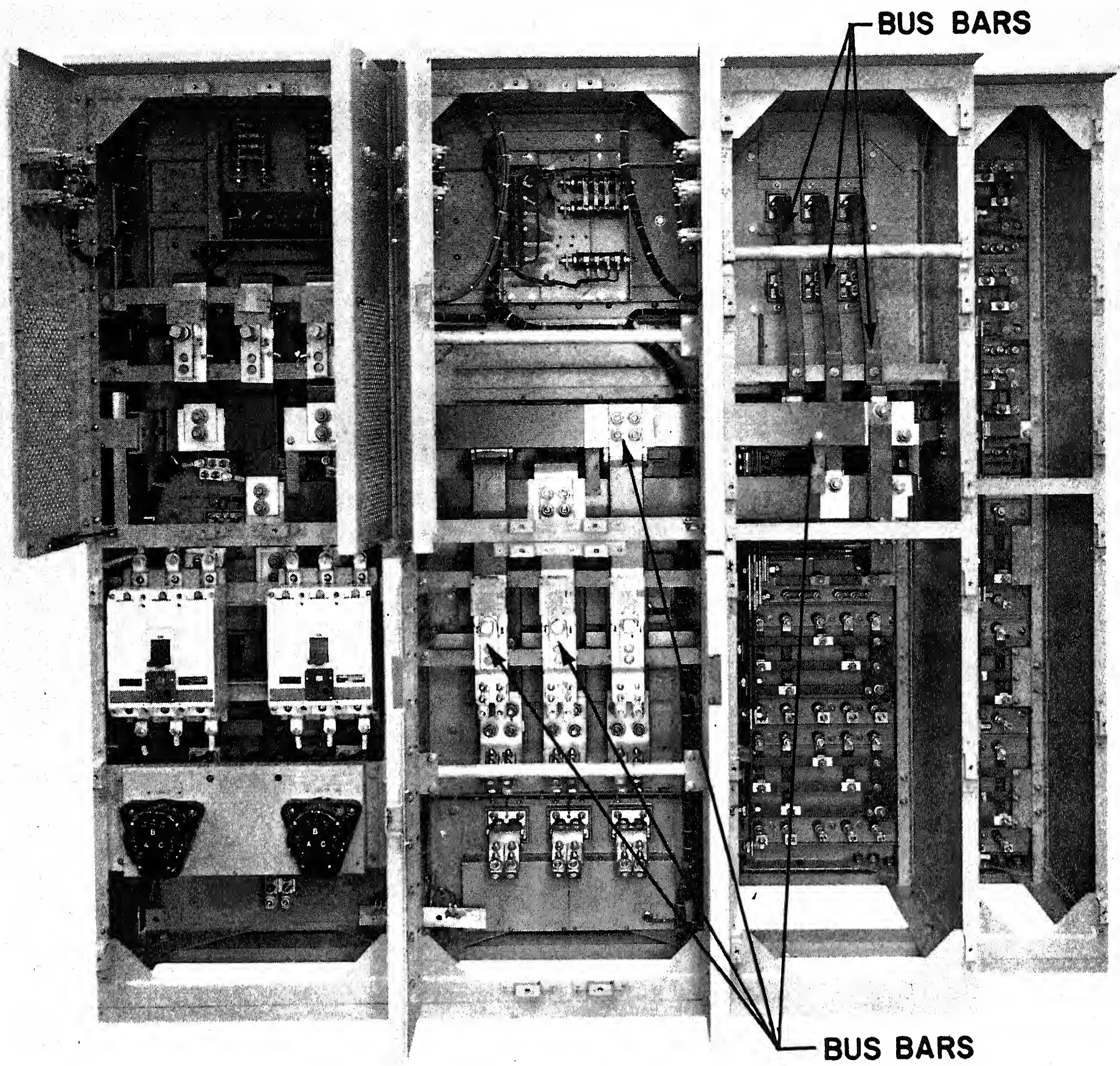

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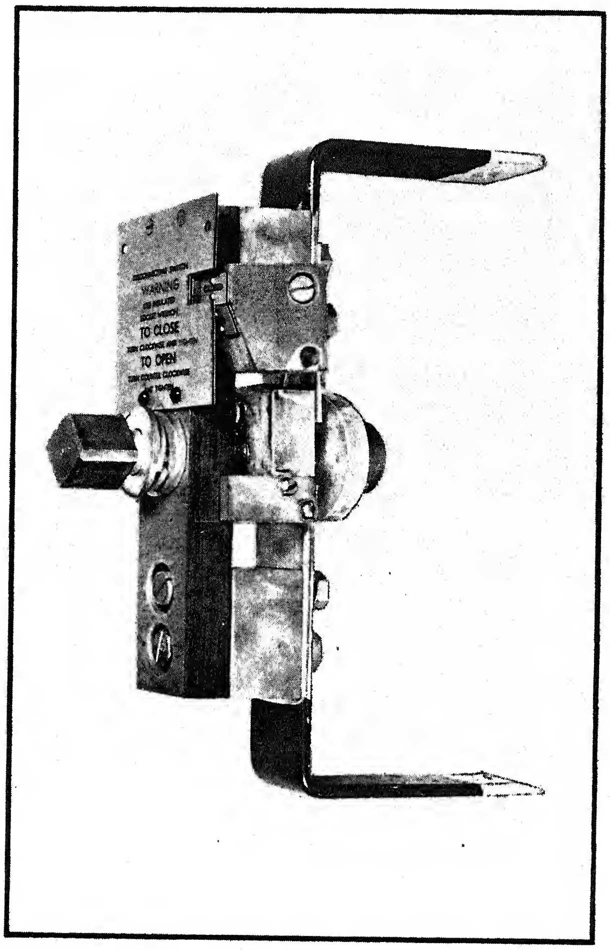
Figure 3-10.—Opened rear view of ship's service switchboard.

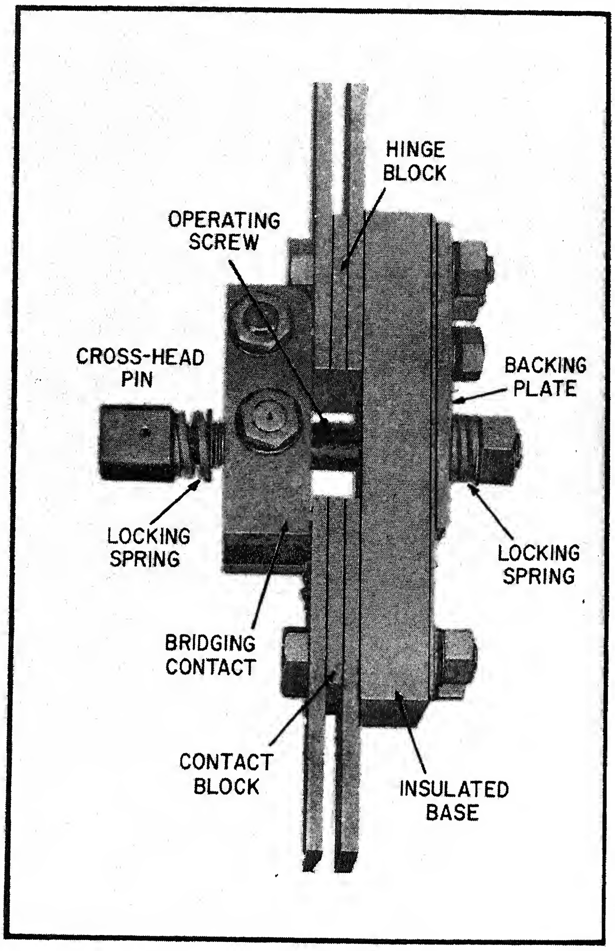
When work is to be performed on a circuit 'eaker, the disconnect link is opened. However, ıu must remember that control power in MOST stallations will still be available at the circuit 'eaker; therefore, the fuses for these devices ıst be pulled before you start to work. These ses are usually located on the back of the /itchboard and are readily accessible.

The screw-type disconnecting links (fig. 3-12) 'e normally located in the rear of the switchboard and are operated by means of an insulated wrench. The disconnect links must be tightened firmly in both the "open" and "closed" positions. CAUTION: Do NOT operate a disconnect link when there is current flowing through the link.

MONITORING DEVICES

Watch standers must have the ability to monitor the equipment for which they are responsible. In





77.2

Figure 3-11.—Disconnect links.

the electrical distribution system many of the monitoring devices are located on the switchboards. Meters, located on the face of the switchboard, (fig. 3-13) monitor speed (frequency), voltage, amperage, phase and speed relation (synchroscope) of two generators being paralleled. Indicator lights for ground detection and breaker position are also located on the switchboard.

CONTROL DEVICES

Switchboards also contain the devices necessary to control the speed of the prime mover (frequency) and the voltage.

The speed of the prime mover (either diesel, steam turbine, or gas turbine) is controlled by a switch, located on the front of the switchboar which operates a governor motor located (the prime mover.

The voltage is controlled by turning a sma rheostat, located on the switchboard, which inser or removes resistance in the voltage regulato:

PROTECTIVE DEVICES

Along with the previously discussed trippin devices incorporated in the circuit breaker the switchboard contains other safety and pro tective devices.

On ships with a.c. ship's service powe systems where the generators are operate

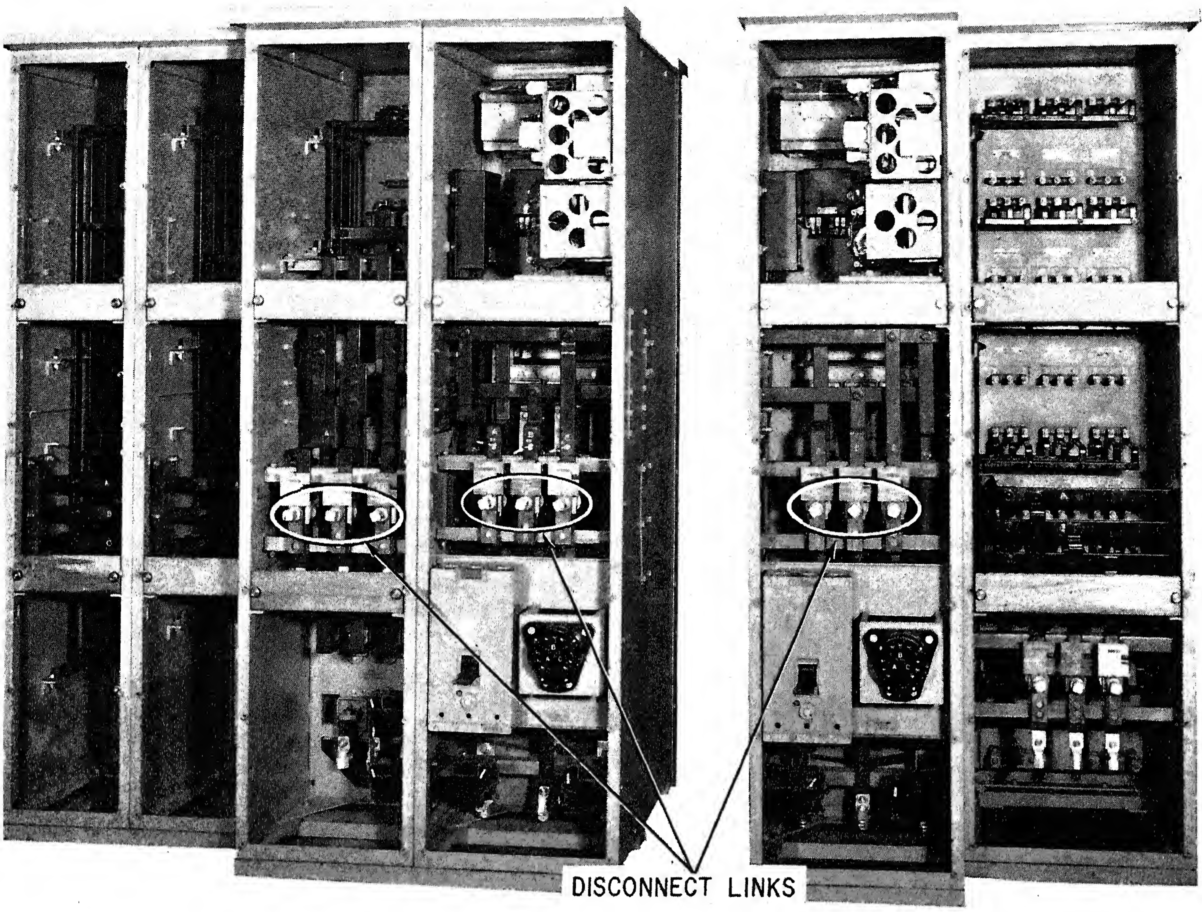


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Figure 3-12.—Rear view ship's service switchboard.

ɔarallel, each generator control unit has a ɜrse power relay. The relay should trip generator circuit breaker in approximately ·econds with reverse power equal to 5 percent ıe generator rating.

Reverse power relays trip the generator ·uit breaker to prevent motoring the generator. ; protection is provided for the prime mover its generator.

n motoring, the faulty generator set will as an additional load for the good generator Motoring can result from a deficiency in prime mover input to the a.c. generator. ; deficiency (insufficient torque) can be caused by loss of steam or low steam to the turbine, lack of fuel to the diesel engine or gas turbine, or other factors which affect the operation of the prime mover. In the absence of reverse power protection, when the input to the generator falls below that needed to maintain required generator speed, power is taken from the ship's service power system, and the generator acts as a motor driving the prime mover.

Fuses are used to protect the monitoring and control devices.

SHORE POWER CONNECTION

The number and locations of shore power connections vary on different types of ships.

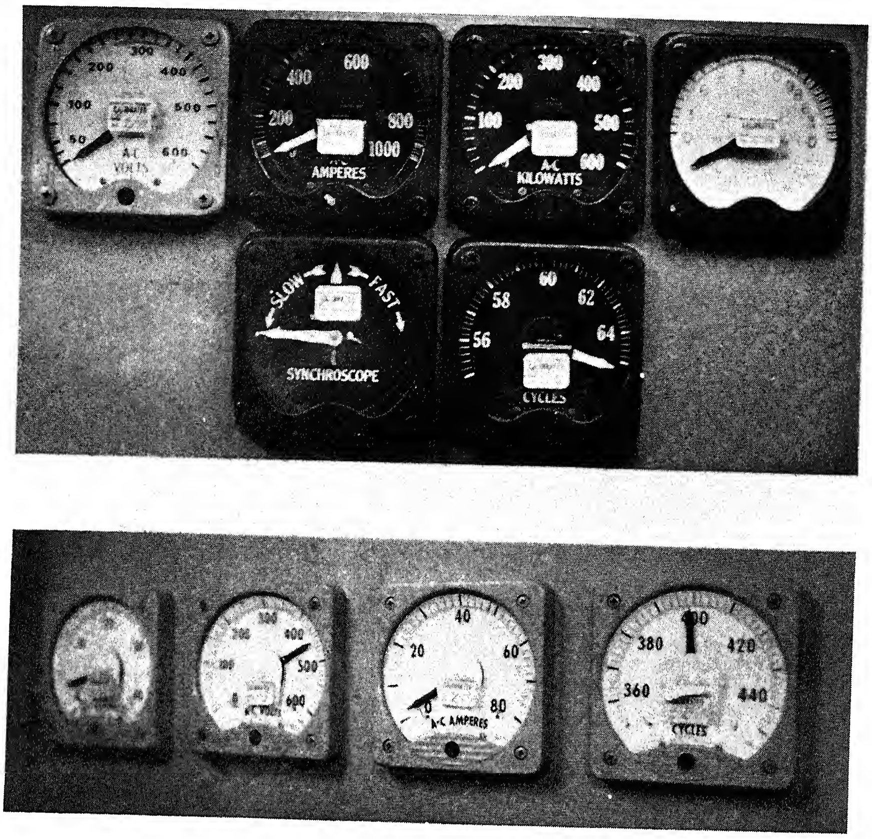

Figure 3-13.—Typical meters on switchboards. 27.35

Shore power connections are provided at, or near, a suitable weather-deck location to which portable cables from the shore or from ships alongside can be connected to supply power for the ship's distribution system when the ship's service generators are not in operation.

Shore power connections are connected to cables which terminate at circuit breakers located on the switchboards. A typical arrangement for shore power circuit breakers on smaller vessels is shown in figure 3-9.

BUS TRANSFER EQUIPMENT

Bus transfer equipment is installed on switchboards, at load centers, distribution panels, or on loads that are fed by both normal and alternat and/or emergency feeders. See fig. 3-14. Thi equipment selects either the normal or alternat source of the ship's service power, or obtain power from the emergency distribution system if an emergency feeder is also provided.

Automatic bus transfer (ABT) equipment i used for loads that require two power supplies except for cold-ship starting of auxiliaries an fire pumps, which have manual bus transfe equipment. On the steering power equipment which is provided with a normal, alternate, an emergency power supply either automatic o manual bus transfer equipment is used to selec between the normal and alternate supplies. The automatic bus transfer equipment is used t select between the ship's service and emergency supplies. On some ships only two sources o steering power are provided—normal and emergency.

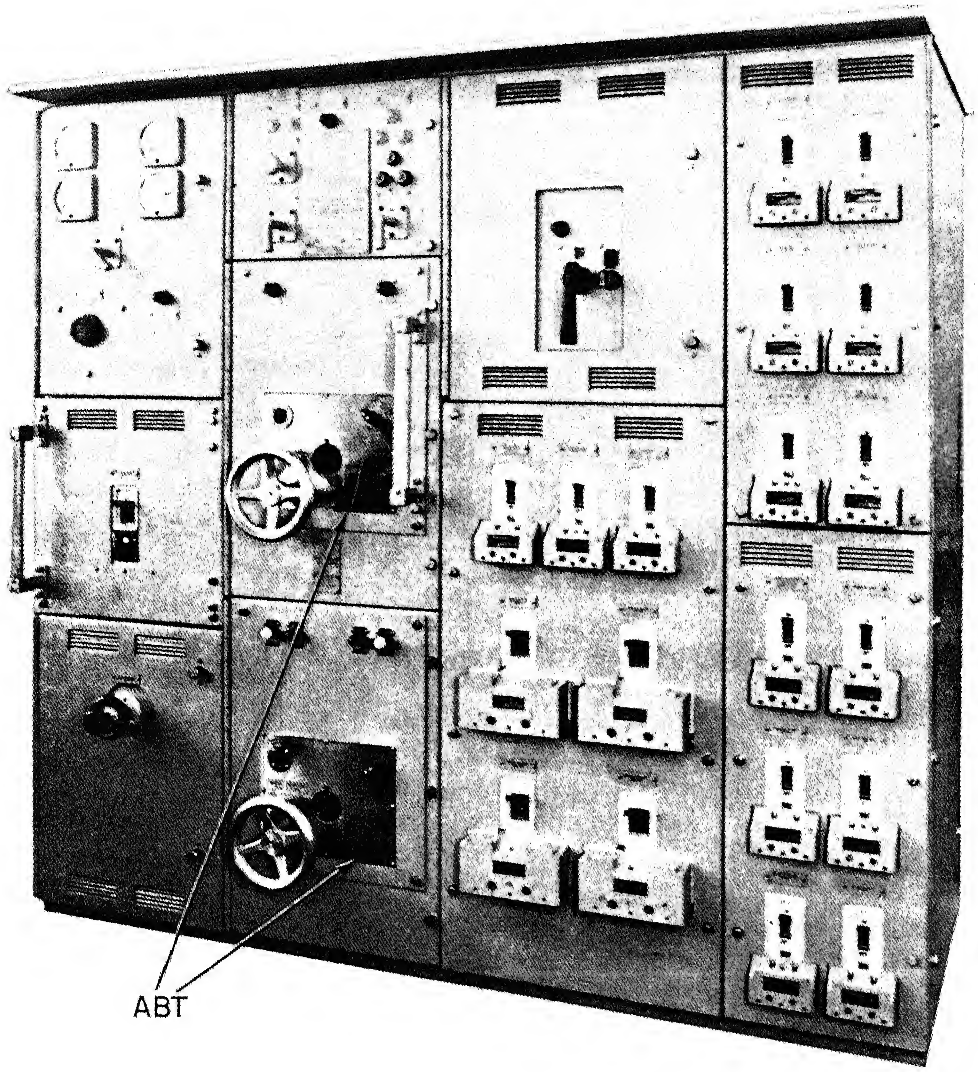

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Figure 3-14.—Emergency switchboard (showing ABT's).

LOAD CENTERS AND POWER PANELS

Load centers and power panels are supplied om the switchboard, which is a branching out the electric power distribution system. Power iginates at the power supply (fig. 3-15) and isses through a generator circuit breaker loited in the main switchboard. On larger ships wer can go to load centers (fig. 3-16) for further stribution to loads. Smaller ships usually inrporate the load centers as a part (sometimes called switchgear groups) of the main switchboard (fig. 3-17). Figure 3-18 shows a typical power panel.

INTERIOR COMMUNICATION DISTRIBUTION

Shipboard interior communications (IC) systems are defined as anything that causes an audible or visual signal to be transferred within

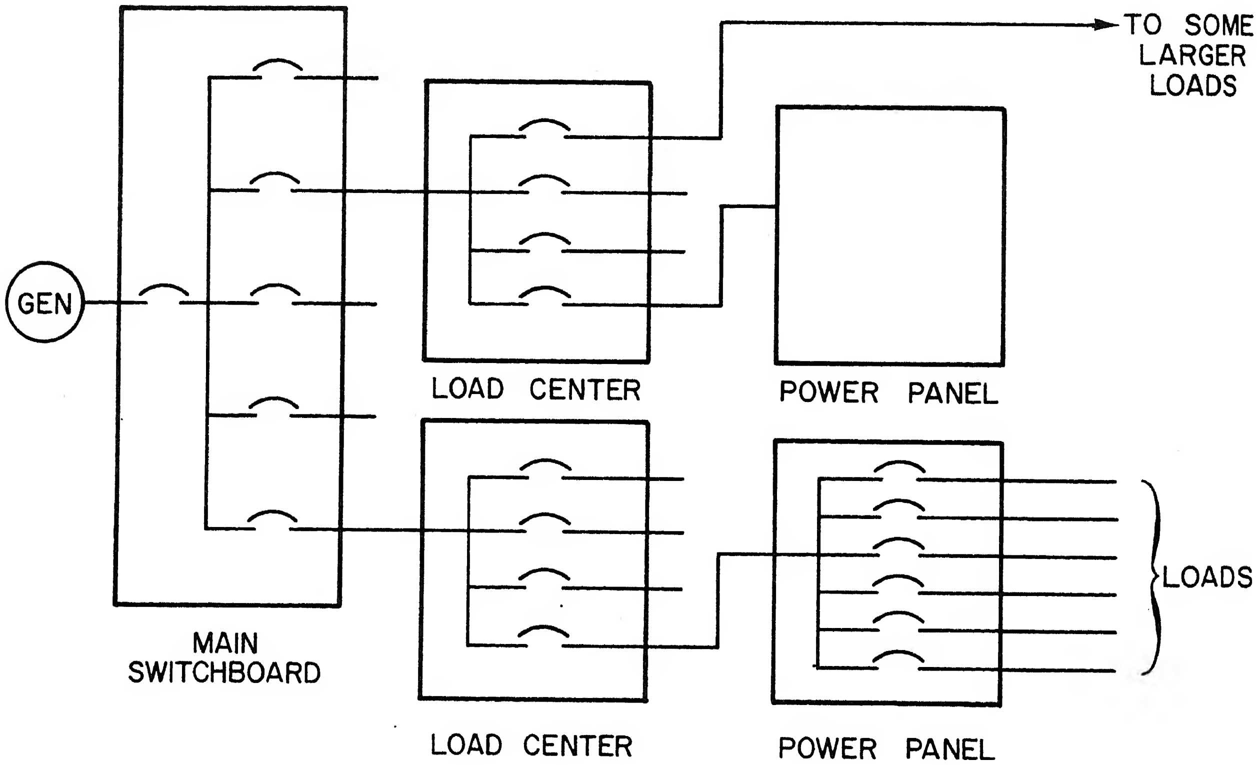

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Figure 3-15.—Line diagram of power distribution (larger ships).

or between the compartments of a ship. They provide a means of exercising command within a ship and include voice interior communications, alarm, warning, ship control, entertainment, gyrocompass, and plotting systems. Although many of the weapons and fire control circuits are supplied by the IC switchboards, these systems are not part of the IC responsibility.

IC SWITCHBOARD

The IC switchboard is the nerve center of the interior communications system. All interior communication and some fire control circuits, including fire control electronic systems, are energized through the IC switchboard.

To obtain maximum protection, most IC switchboards are installed below the waterline and are energized from a normal, an alternate, and an emergency power supply to ensure continuous service.

In large combatant ships there are two main IC switchboards. One switchboard is located in the forward IC room, and the other switchboard is located in the after IC and gyro room. Thus, each system or equipment receives its normal supply from the nearer IC switchboard. The after main IC switchboard is usually arranged similarly to the forward main board, except that in the after IC room some of the special buses such as the controlled-frequency bus may be omitted.

In the older ships, separate IC and action cutout (ACO) switchboards are installed. In new construction ships, IC switchboards are composed of power control distribution and ACO sections.

The latest type IC switchboard is the front-service IC board (fig. 3-19) which is constructed so that installation, operation, and maintenance

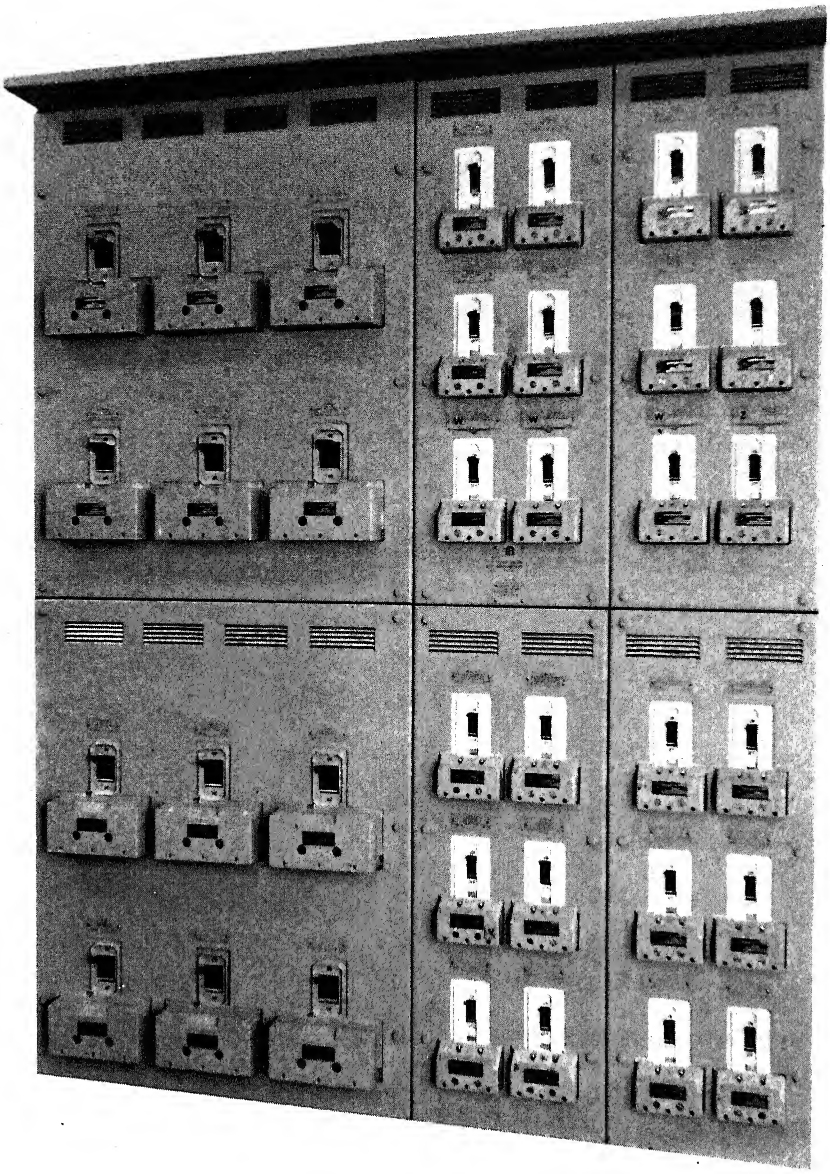

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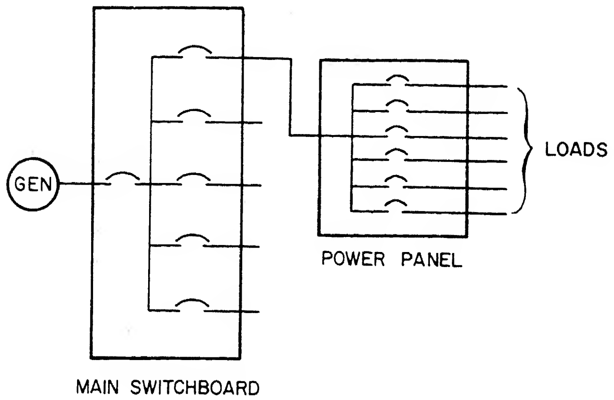
Figure 3-16.—Load center switchboard.

an be accomplished entirely from the front of ıe switchboard. The front-service design uses box-type construction with hinged front panels. witches and fuse holders up to 60-ampere apacity and other relatively light items are ıounted on the hinged panels, while heavier items re mounted behind removable panels.

Terminal boards within the switchboard enlosure provide for termination of all ship's cables except for a few of the larger cables, which run directly to their associated switches and fuse holders. All wiring between the terminal boards and the equipment mounted on both the hinged and stationary panels is installed by the switchboard manufacturer to permit free swinging of the panels without interference from, or damage to, the wiring harness.

To reduce the rigidity of the switchboard and to permit separate movement of panels



27.66
Figure 3-17.—Line diagram of power distribution (smaller ship).

during shock, cables are used instead of horizontal buses for connections between or among switchboard sections. Some vertical buses may be used, however, to supply sections of the individual panel.

The principal advantage of the front-service IC switchboard is that it can be mounted against a bulkhead because no access space is required in the rear of the board. This feature results in a saving of space, which is most important aboard ship.

The action cutout (ACO) section permits isolation of various portions of IC systems and in addition, allows transfer control of certain systems from one station to another. Separate switchboards are usually provided for specialized systems such as the sound-powered telephone system.

In older combatant vessels the ACO switchboard (one or more sections) is located in the central section, which also functions as damage control central. On new construction ships, damage control central is combined with engineering central (log room) and is located nearer to the engineering plant and farther from the IC room. However, the ACO section is located in the IC room and is part of the IC switchboard.

A front-service ACO section is shown in figure 3-20. Drawout switch units are utilized with each unit incorporating the associated fuse holders and overload indicators.

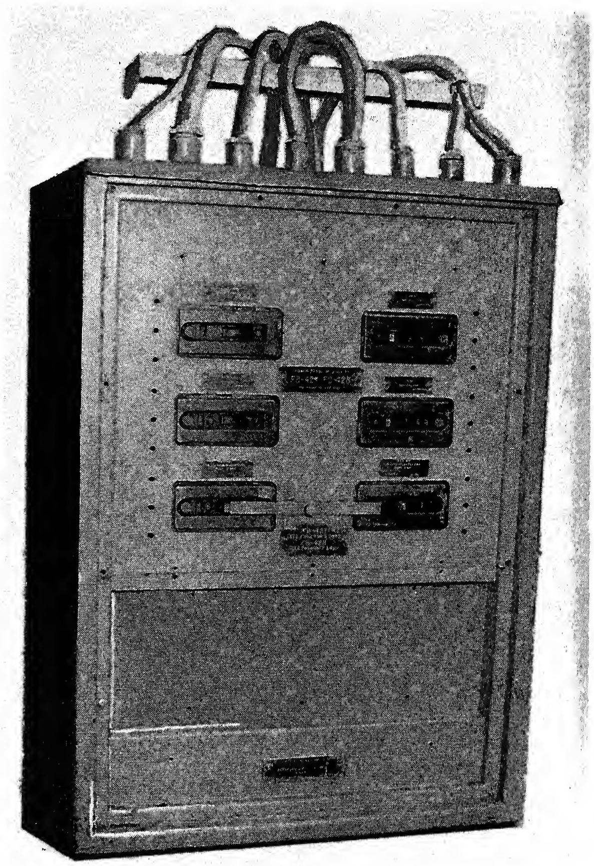


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Figure 3-18. — Typical power panel.

IC SWITCHBOARD
POWER SUPPLY

The power distribution systems and arrangements of buses of IC switchboards vary widely in different ships, dependent of the size and mission of the ship, the main power system, and the fire control (FC) system. The following discussion describes the general principles of a typical IC switchboard power supply.

The forward main IC switchboard is supplied with power from as many sources as possible. The power supply usually consists of (1) a normal supply from a main power distribution

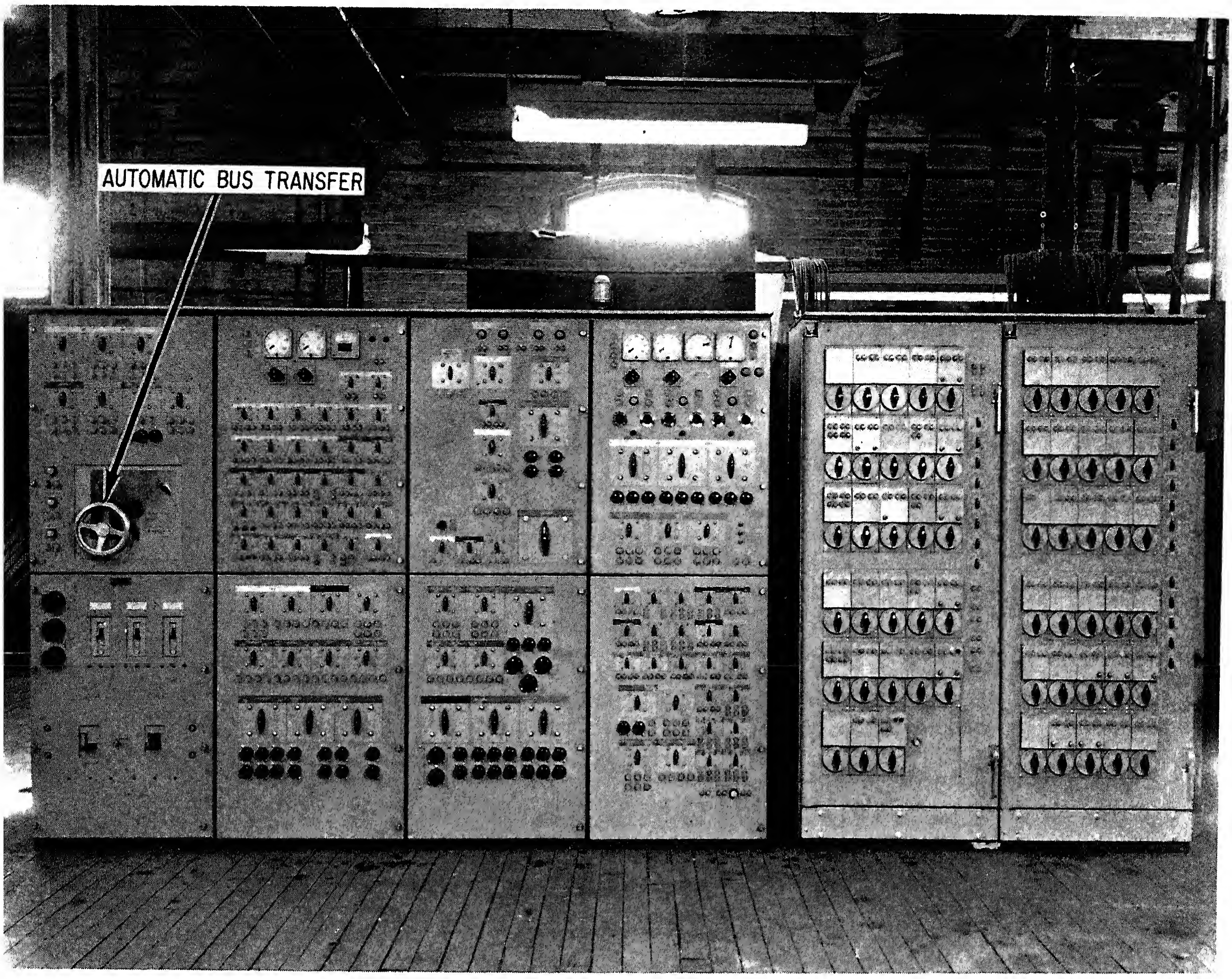

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Figure 3-19.— Front-service main IC switchboard.

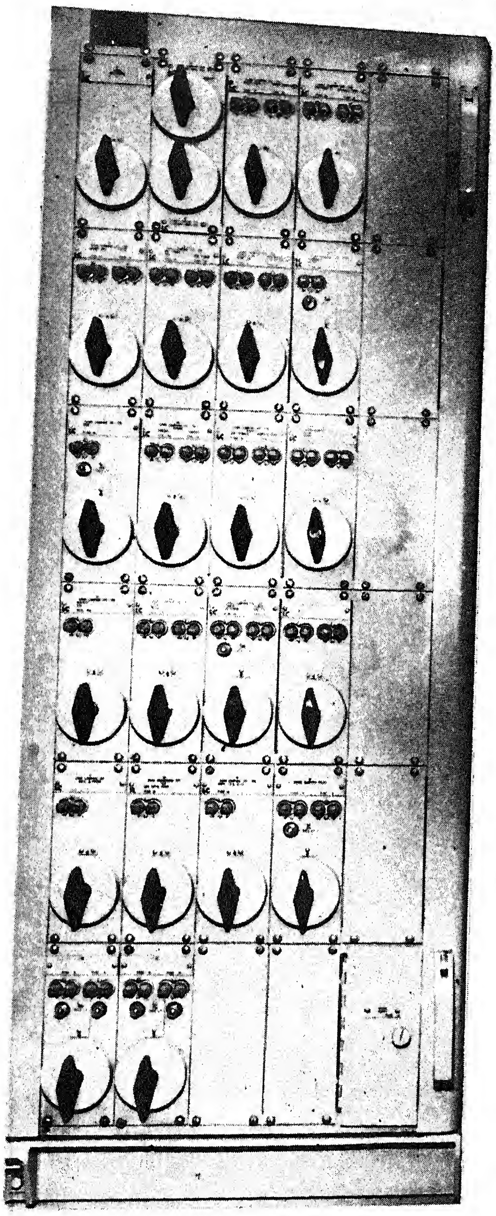
witchboard of the forward machinery group, 2) an alternate supply from a main power distribution switchboard of the after machinery roup, and (3) an emergency supply from the earer emergency-distribution switchboard.

The normal 3-phase, 450-volt, 60-Hz power upply is obtained from the forward main ship's ervice distribution switchboard through an ACB ircuit breaker on that board. The 450-volt supply s connected to a 450-volt bus on the main IC witchboard through the bus-transfer switch ABT), as shown in figure 3-14.

The 450-volt bus energizes the various 450-olt, 60-Hz circuits through individual switches and fuses. In this installation the 450/120-volt 60-Hz transformer bank is energized directly from the 450-volt bus through fuses. However, in some installations the transformers are energized through a switch and fuse combination.

The IC transformer bank is connected delta-delta in order to operate open-delta in case of a casualty to one transformer (discussed in chapter 5 of this training manual). When operating open-delta, strip the switchboard of all but the vital circuits. The load can be reduced as necessary by opening the switches of less essential circuits.

In some ships in which the emergency power is extremely small, the main 120-volt a.c. bus



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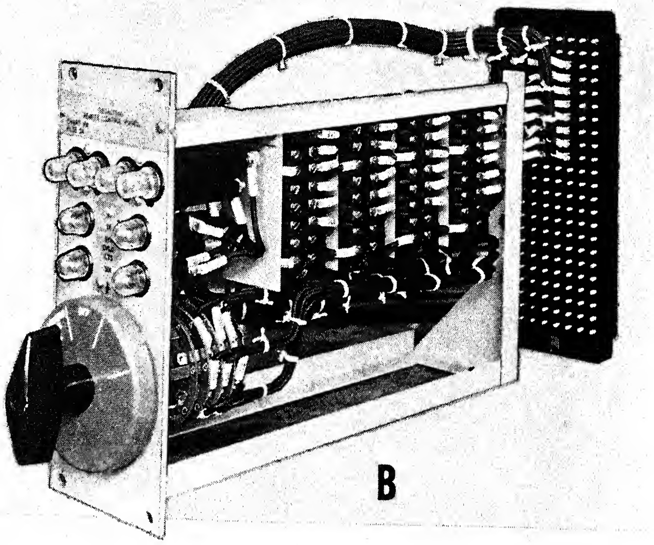

B

55.31(

Figure 3-20. — Front view of front-service switchboard.

is divided into a general and a restricted bus. The restricted bus supplies power to the most important circuits as well as to the IC and FC buses, which are connected to the restricted bus through manual switches or contactors. The contactors open automatically upon transfer to the emergency power supply. Thus, the normal 120-volt supply is disconnected from the IC and FC buses upon transfer to the emergency supply. After the switches for less essential circuits or

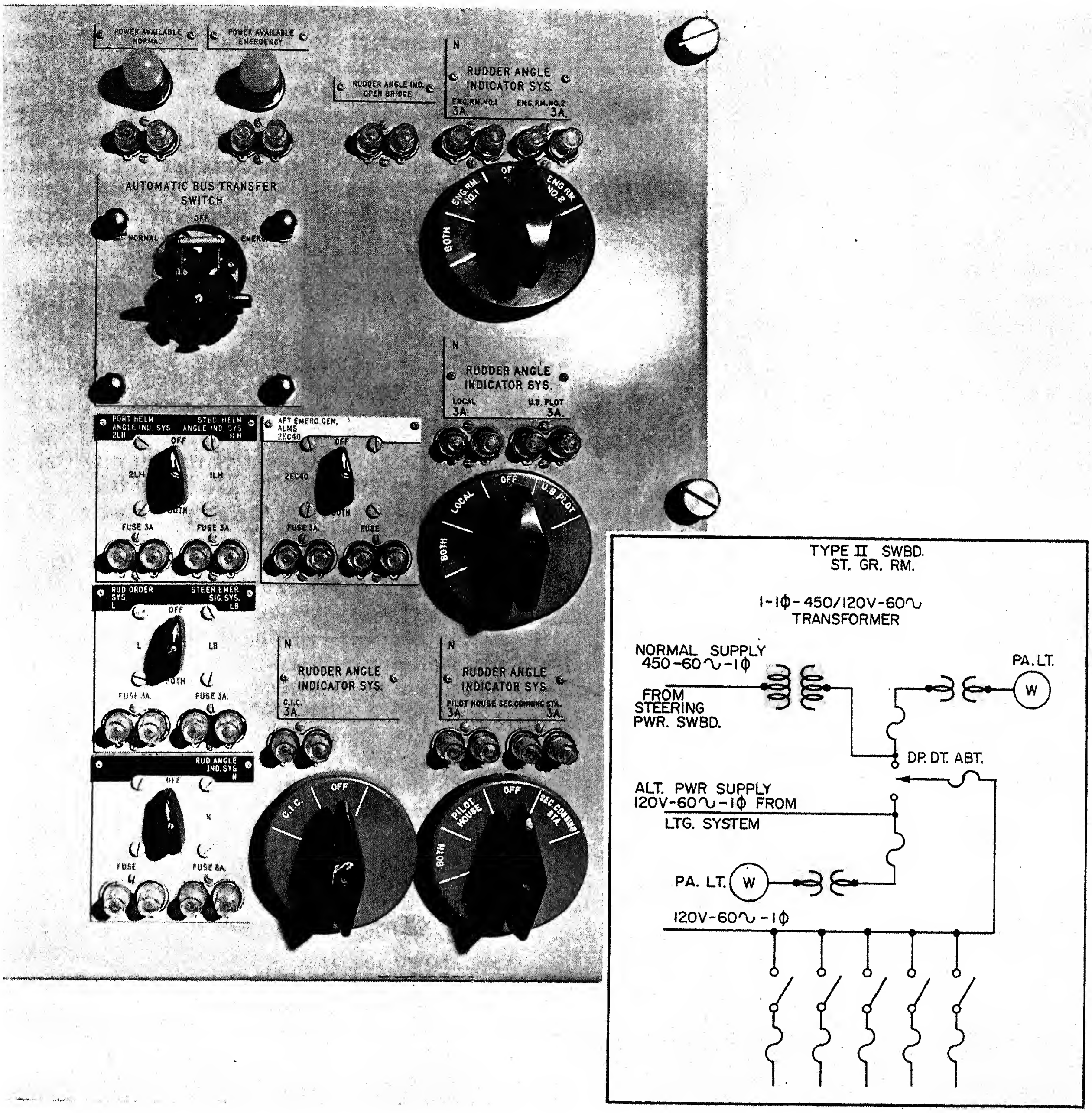

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Figure 3-21. — Local IC switchboard.

IC and FC buses have been opened to reduce load, the contactors supplying these buses closed again.

There are two 400-Hz closely regulated bus tions — 450-volt and 120-volt. The 450-volt section may be supplied by a motor generator or a static power supply which receives its power from the 450-volt, 60-Hz bus at its associated switchboard. The 120-volt, 400-Hz section of each switchboard receives its power from a

delta-delta connected bank of transformers, which are connected to the respective 450-volt, 400 Hz sections. A d.c. section receives its power supply from a 120-VDC rectifier.

LOCAL IC SWITCHBOARDS

A local IC switchboard is usually provided in each engineroom to energize local IC circuits. The normal supply for each switchboard is from the nearer main IC switchboard. The emergency supply for each switchboard is from a local emergency lighting circuit. This arrangement provides the switchboard with the same power backup as that of the main IC switchboard. However, in case of loss of power at the main IC switchboard or damage to the connecting cable, the local switchboards can still be energized from an alternate source. Automatic bus transfer switches are provided on the IC switchboards in the engineroom and steering gear room on newer ships to minimize interruptions if the normal power source is lost. Action cutout switches are provided to disconnect equipment that is connected to local transmitters.

A local IC switchboard (fig. 3-21) is usually installed in each steering gear room to energize all circuits associated with steering-order and rudder-angle indicator systems. The normal supply for this switchboard is from the steering-power transfer switchboard through a local transformer. An alternate supply is taken from a local emergency lighting circuit to provide power if the normal supply is lost.

CLASSIFICATION OF CIRCUITS

IC circuits are classified according to importance and to readiness.

Each IC circuit is classified into one of the following three groups according to its importance.

VITAL CIRCUITS are those circuits th are essential to the fighting effectiveness the ship. The loss of a vital circuit, such the gyrocompass system, would seriously impa fighting effectiveness.

SEMIVITAL CIRCUITS are those circui that are very important but not essential fighting effectiveness. The loss of a semivit circuit, such as the auxiliary battle telepho system, would impair fighting effectiveness le than the loss of a vital circuit.

NONVITAL CIRCUITS are those circuits th are not essential to fighting effectiveness. T loss of a nonvital circuit, such as the boile feed signal system, would not impair fighti effectiveness.

Each IC circuit is classified into one of t following four groups according to its readine

CLASS 1 CIRCUITS are those that are esse tial to the safety of the ship. These circuits a energized at all times.

CLASS 2 CIRCUITS are those that (along wi class 1 circuits) are essential to ship contr These circuits are energized during the prep ration period for getting underway, while standi by, while underway, and until the ship is secur after coming to anchor.

CLASS 3 CIRCUITS, or BATTLE CIRCUIT are those that (along with class 1 and class circuits) are essential to complete interior co trol. These circuits are energized during co dition watches.

CLASS 4 CIRCUITS are the convenience ci cuits that are energized only when require such as ship's entertainment system.

Supply switches on IC switchboards are color as shown to identify readily the class of circui

Class 1. . .Yellow — continuously energized
Class 2. . .Black — underway circuits
Class 3. . .Red — battle circuits
Class 4. . .White — convenience circuits

CHAPTER 4

MOTORS AND CONTROLLERS

Electric motors and controllers are a vital rt of a ship's operating ability. They provide e mechanical power for many purposes ranging om large horsepower pumps and compressors small fractional horsepower motors for fans d portable tools. Most electric motors are nnected to the power supply lines through a ntroller (starter) which controls and protects e motor.

In this chapter we shall describe the basic eration of motors, their construction, appli- tion, and the control devices associated with em.

DC MOTORS

There is very little difference in basic con- uction between a d.c. motor and a d.c. generator g. 4-1). A generator is rotated by a prime ver to convert mechanical energy to electrical ergy, whereas a motor is connected to a source electrical power and converts electrical energy mechanical energy. A d.c. generator may made to function as a motor if you apply suitable source of direct voltage across the rmal output electrical terminals as described no-break power supplies.

The operation of a d.c. motor depends on principle that a current-carrying conductor ced within, and at right angles to, a magnetic ld tends to move at right angles to the direction he field, as shown in figure 4-2.

The magnetic field between the north and south poles of a magnet is shown in figure 2A. The lines of force comprising the field end from the north pole to the south pole. cross section of a current-carrying conductor re) is shown in figure 4-2B. The plus sign hin the wire indicates that the electron flow is away from the observer. The flux loops counterclockwise around the wire, as shown. This follows the left-hand rule which states that if the conductor is grasped in the left hand with the thumb extended in the direction of the current flow, the fingers will curve around the conductor in the direction of the magnetic flux.

If the conductor (carrying the electron flow away from the observer) is placed between the poles of the magnet, as in figure 4-2C, both fields will be distorted. Above the wire the field is weakened, and the conductor tends to move upward. The force exerted depends on the strength of the field between the poles and on the strength of the current flowing through the wire.

If the current through the conductor is reversed, as in figure 4-2D, the direction of the flux loops around the wire is reversed. The field below the conductor is now weakened, and the conductor tends to move downward. This force, which acts on the conductor under these conditions, is directly proportional to the strength of the magnetic field, the magnitude of the current, and the length of the conductor.

Since a motor is a rotating machine, the force exerted on the armature conductor is expressed in torque as measured at the motor shaft. The torque for a given motor is therefore directly proportional to the armature current and the strength of the magnetic field.

The various types of d.c. motors (fig. 4-3) are identified by the way the field coils are connected. Each type has characteristics that are advantageous under given load conditions.

SHUNT MOTORS

In figure 4-3A the field coils are connected in parallel with the armature circuit. This type

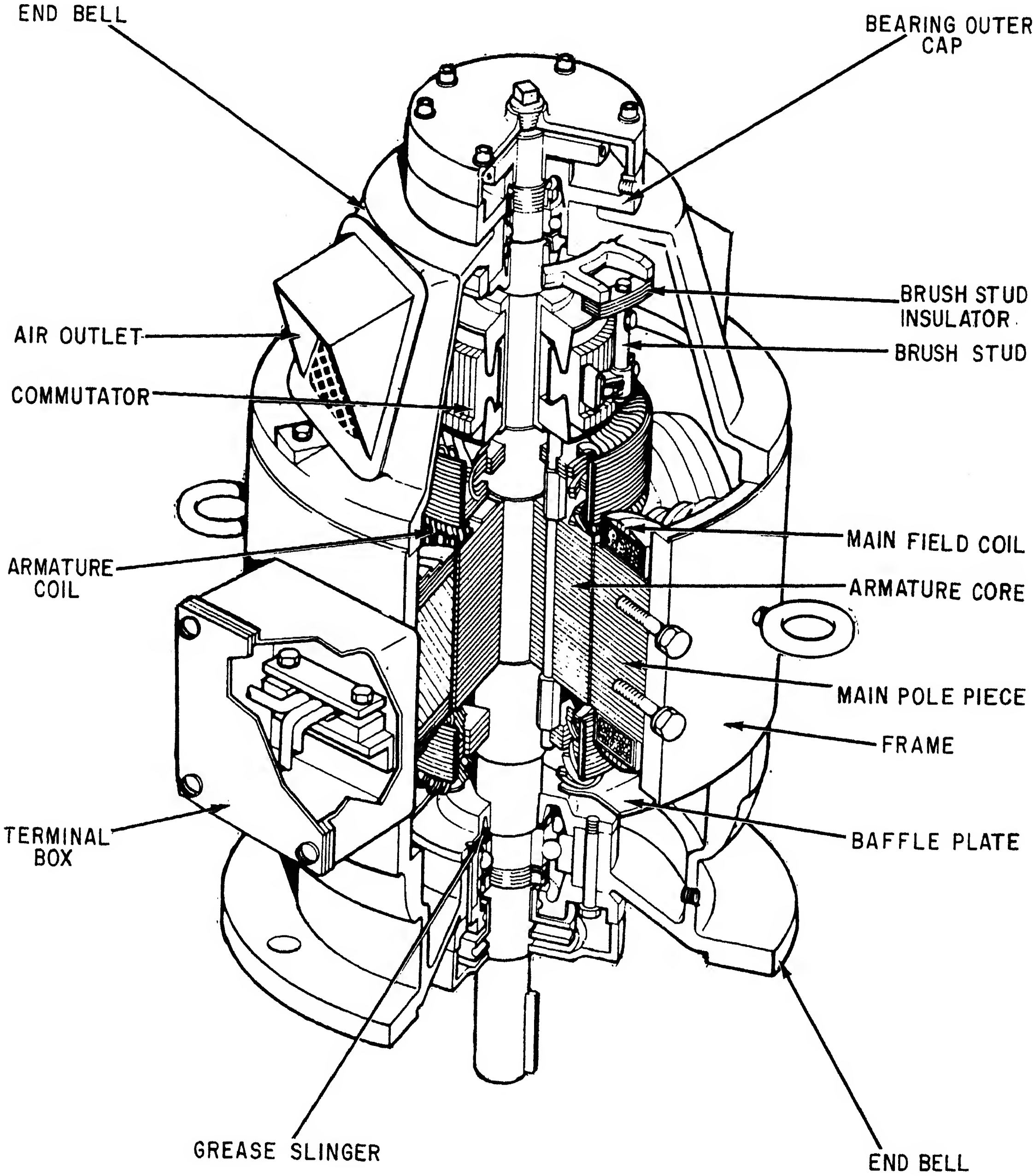

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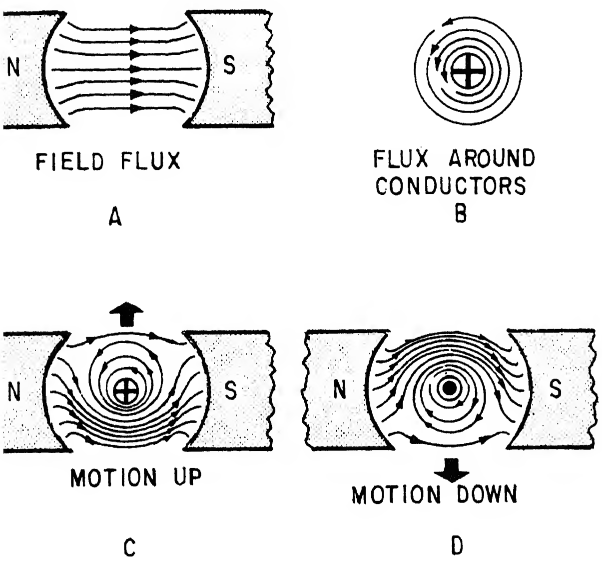
Figure 4-1.—D.c. motor.

motor, with constant potential (voltage) applied, develops variable torque at an essentially constant speed, even under changing load conditions. Such loads are found in machine shop motors and include lathes, milling machines, drills, planers, shapers, and so forth.

SERIES MOTORS

In figure 4-3B the field coils are connected in series with the armature circuit. This type motor, with constant potential applied, develops variable torque, but its speed varies widely



236.359
gure 4-2.—Force acting on a current-carrying conductor in a magnetic field.

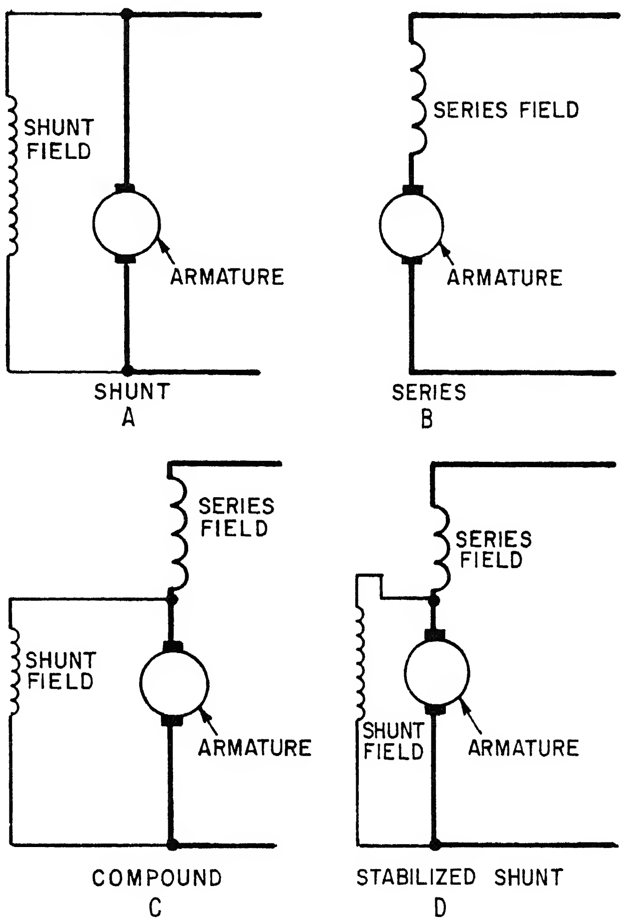
ıder changing load conditions. That is, the ıeed is low under heavy loads but becomes :cessively high under light loads. Series motors 'e commonly used to drive electric cranes, ıists, winches, and certain types of vehicles ɔr example, electric trucks). Series motors 'e used extensively to start internal combustion ıgines. CAUTION: A series motor that is run .thout load will destroy itself by overspeed.

ƆMPOUND MOTORS

Figure 4-3C shows a compound motor—a ımpromise between shunt and series motors. ıe set of field coils is connected in parallel th the armature circuit, and the other set field coils is connected in series with the mature circuit. A compound motor develops . increased starting torque over that of the unt motor and has less variation in speed an the series motor. Shunt, series, and com- ɪund motors are all d.c. motors designed operate from constant-potential, variable- rrent d.c. sources.

'ABILIZED SHUNT MOTORS

Figure 4-3D shows a stabilized shunt motor—a ɡht series winding in addition to the shunt field. The action is similar to ordinary shunt motors except stabilized shunt motors have better torque characteristics with less field iron and therefore are lighter in weight.



236.356
Figure 4-3.—Schematic diagrams of four types of d.c. motors.

AC MOTORS

The majority of Navy ships utilize a.c. motors for electromechanical energy for several reasons. As previously discussed, most ship's service generators produce alternating current, thus making it readily available. Also a.c. motors are generally less expensive than d.c. motors. Most types of a.c. motors do not employ brushes and commutators, thereby eliminating dangerous sparking as well as the many problems of maintenance and wear.

A.c. motors are designed for use with polyphase or single-phase power systems and come in many different sizes, shapes, and ratings. We cannot possibly cover all a.c. motors in this chapter. Consequently, we shall deal with the operating principles and applications of the four most common types found aboard ship: the polyphase induction motor and the single phase motors which include the split-phase motor, the capacitor motor, and the universal motor.

So that you will better understand the operating principles of polyphase induction motors, let us briefly discuss the a.c. theory. Referring to figure 4-4 you will see the manner in which a rotating field is produced by stationary coils, or windings, when they are supplied by a 3-phase power source. For purposes of explanation, rotation of the field is developed in figure 4-4 by "stopping" it at six selected positions, or instants. These instants are marked off at 60° intervals on the sine waves, representing currents in the three phases A, B, and C.

At instant (1) the current in phase B is maximum positive. (Assume plus 10 amperes in this example). Current is considered to be positive when it is flowing out from a motor terminal. At the same time (instant 1) current flows into the A and C terminals at half value (minus 5 amperes each in this case). These currents combine at the neutral (common connection) to supply plus 10 amperes out through the B phase.

The resulting field at instant (1) is established downward and to the right, as shown by the arrow NS. The major portion of this field is produced by phase B (full strength at this time) and is aided by the adjacent phases A and C (half strength). The weaker portions of the field are indicated by the letters "n" and "s." The field is two-pole extending across the space that would normally contain the rotor.

At instant (2) the current in phase B is reduced to half value (plus 5 amperes in this example). The current in phase C has reversed its flow from minus 5 amperes to plus 5 amperes and the current in phase A has increased from minus 5 to minus 10 amperes.

The resulting field at instant (2) is now established upward and to the right, as shown by the arrow NS. The major portion of the field is produced by phase A (full strength), and the weaker portions are produced by phases B and C (half strength).

At instant (3) the current in phase C is plus 10 amperes and the field extends vertically upward; at instant (4) the current in phase B becomes minus 10 amperes, and the field extends upward and to the left; at instant (5) the current in phase A becomes plus 10 amperes, and the field extends downward and to the left; at instant (6) the current in phase C is minus 10 amperes, and the field extends vertically downward. Instant (7) (not shown) corresponds to instant (1) when the field again extends downward and to the right.

Thus, a full rotation of the two-pole field has been accomplished through one full cycle of 360 electrical degrees of the 3-phase currents flowing in the windings.

POLYPHASE INDUCTION MOTORS

The driving torque of both d.c. and a.c. motors is derived from the reaction of current-carrying conductors in a magnetic field. You will recall that in the d.c. motor the magnetic field is stationary and the armature, with its current-carrying conductors, rotates. The current is supplied to the armature through a commutator and brushes.

In induction motors (fig. 4-5) the rotor currents are supplied by electromagnetic induction. The stator windings (coils) receive the 3-phase power and produce the previously mentioned rotating magnetic field. The magnetic field rotates continuously at constant speed (synchronous) regardless of the load on the motor. The rotor is not connected electrically to the power supply. The induction motor derives its name from the fact that electromagnetic induction takes place between the stator and the rotor under operating conditions. The magnetic revolving field produced by the stator cuts across the rotor conductors, thereby inducing a voltage in the conductors. The induced voltage causes rotor current to flow. Hence, motor torque is developed by the interaction of the rotor's magnetic field and the stator's revolving magnetic field.

Most larger a.c. motors which are used on naval ships are polyphase (3-phase) induction motors.

Figure 4-6 shows the rotor and stator of a typical polyphase induction motor.

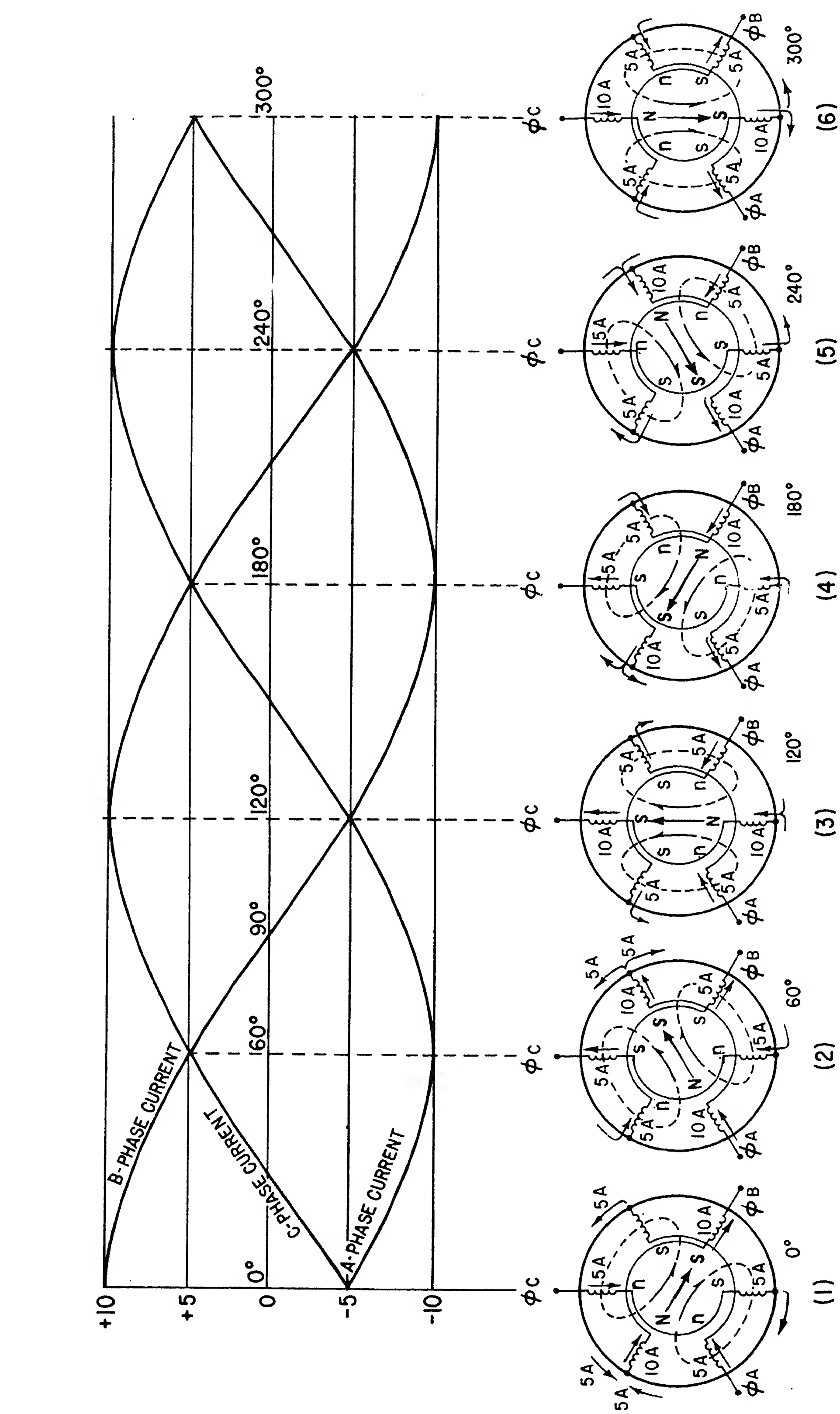


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Figure 4-4.—Development of a rotating field.

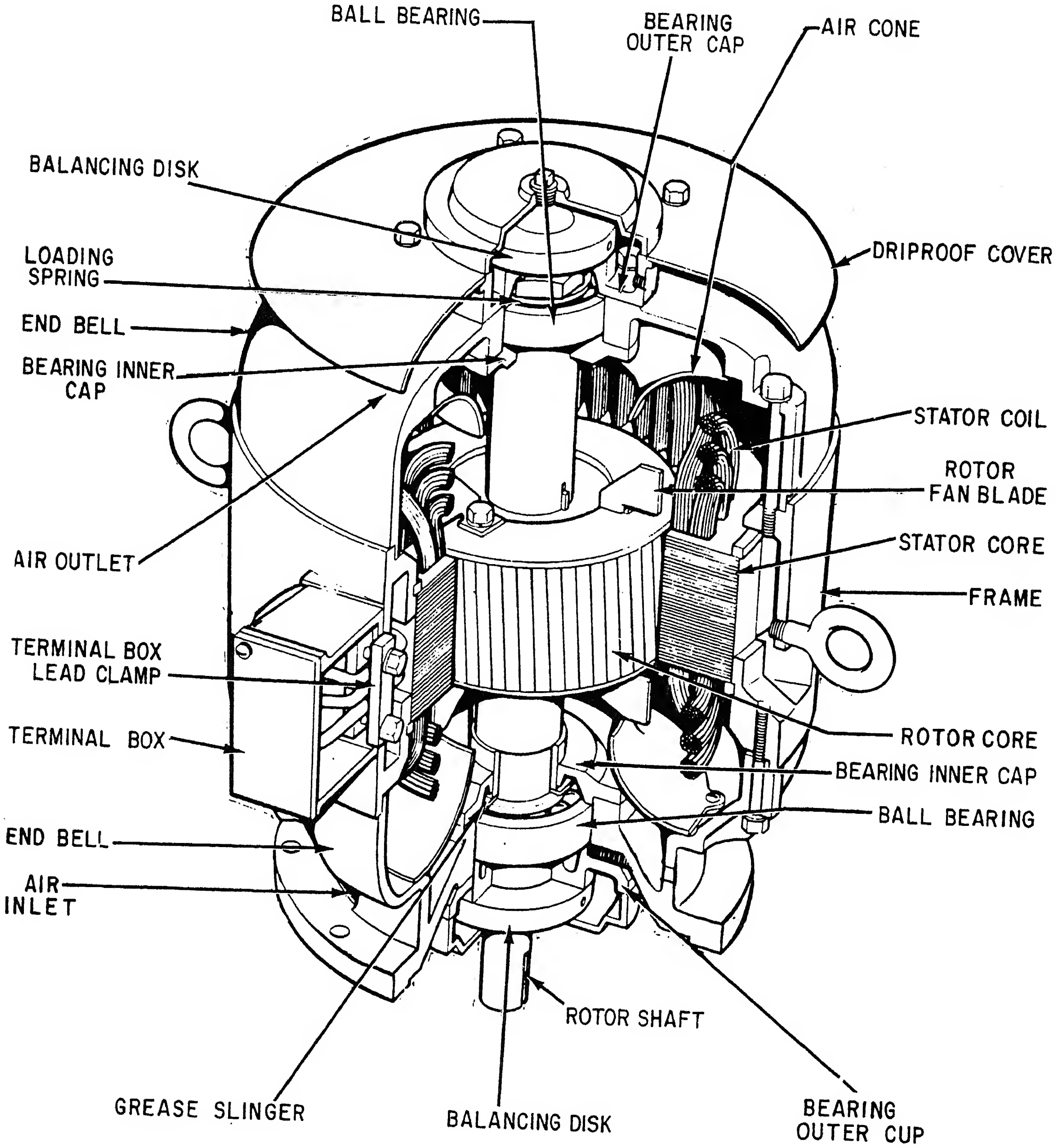
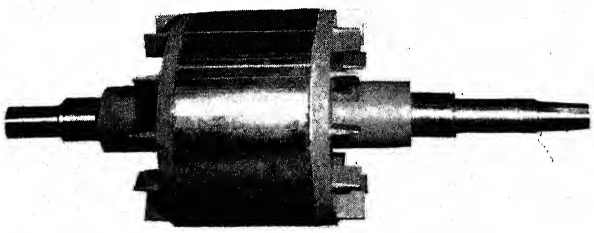


Figure 4-5.—3-phase induction motor. 73.161

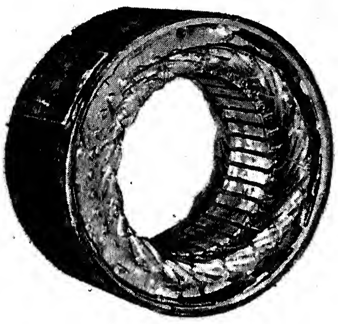
SINGLE-PHASE MOTORS

Single-phase motors, as their name implies, operate on a single-phase power supply. These motors are used extensively in fractional horsepower sizes in commercial and domestic applications. The advantages of using single-phase motors in small sizes are that they are less expensive to manufacture than other types, and they eliminate the need for 3-phase a.c. lines. Single-phase motors are used in interior communications equipment, fans, refrigerators, portable drills, grinders, and so forth.

A single-phase induction motor with only one stator winding and a cage rotor is like the



A. ROTOR



B. STATOR

73.147-77.77
Figure 4-6.—Typical polyphase induction motor (stator and rotor).

3-phase induction motor with a cage rotor except that the single-phase motor has no revolving magnetic field at start, hence, no starting torque. However, if the rotor is brought up to speed by external means, the induced currents in the rotor will cooperate with the stator currents to produce a revolving field. This causes the rotor to continue to run in the direction in which it was started.

Several methods are used to provide the single-phase motor with starting torque. These methods identify the motor as split phase, capacitor, etc. Another single-phase motor, which we shall discuss later, is the a.c. series motor (universal).

SPLIT-PHASE MOTOR

The split-phase motor (fig. 4-7A) has a stator composed of slotted laminations which contain an auxiliary (starting) winding and a running (main) winding. The axes of these two windings are displaced by an angle of 90 electrical degrees. The starting winding has fewer turns and smaller wire than the running winding; hence, the starting winding has higher resistance and less reactance. The main winding occupies the lower half of the slots, and the starting winding occupies the upper half. The two windings are connected in parallel across the single-phase line which supplies the motor. The motor derives its name from the action of the stator during the starting period. The single-phase stator is split into two windings (phases), which are displaced in space by 90°, and which contain currents displaced in time phase by an angle of approximately 15° (fig. 4-7B). In the starting winding, current I_S lags the line voltage by approximately 30° and is less than the current in the main winding because of the higher impedance (AC resistance) of the starting winding. In the main winding, the current, I_M lags the applied voltage by approximately 45°. The total current, I_{line}, during the starting period is the vector sum of I_S and I_M.

At start, these two windings produce a magnetic revolving field which rotates around the stator air-gap at synchronous speed. As the rotating field moves around the airgap, it cuts across the rotor conductors and induces a voltage in them, which is maximum in the area of highest field intensity and, therefore, is in phase with the stator field. The rotor current lags the rotor voltage at start by an angle that approaches 90° because of the high rotor reactance. The interaction of the rotor currents and the stator field causes the rotor to accelerate in the direction in which the stator field is rotating. During acceleration the rotor voltage, current, and reactance are reduced, and the rotor currents come closer to an inphase relation with the stator field.

When the rotor has come up to approximately 75 percent of synchronous speed, a centrifugally operated switch (fig. 4-8) disconnects the starting winding from the line supply, and the motor continues to run on the main winding alone. Thereafter, the rotating field is maintained by the interaction of the rotor magnetomotive force and the stator magnetomotive force. These two mmf's are pictured as the vertical and horizontal vectors respectively in the schematic diagram in figure 4-7C.

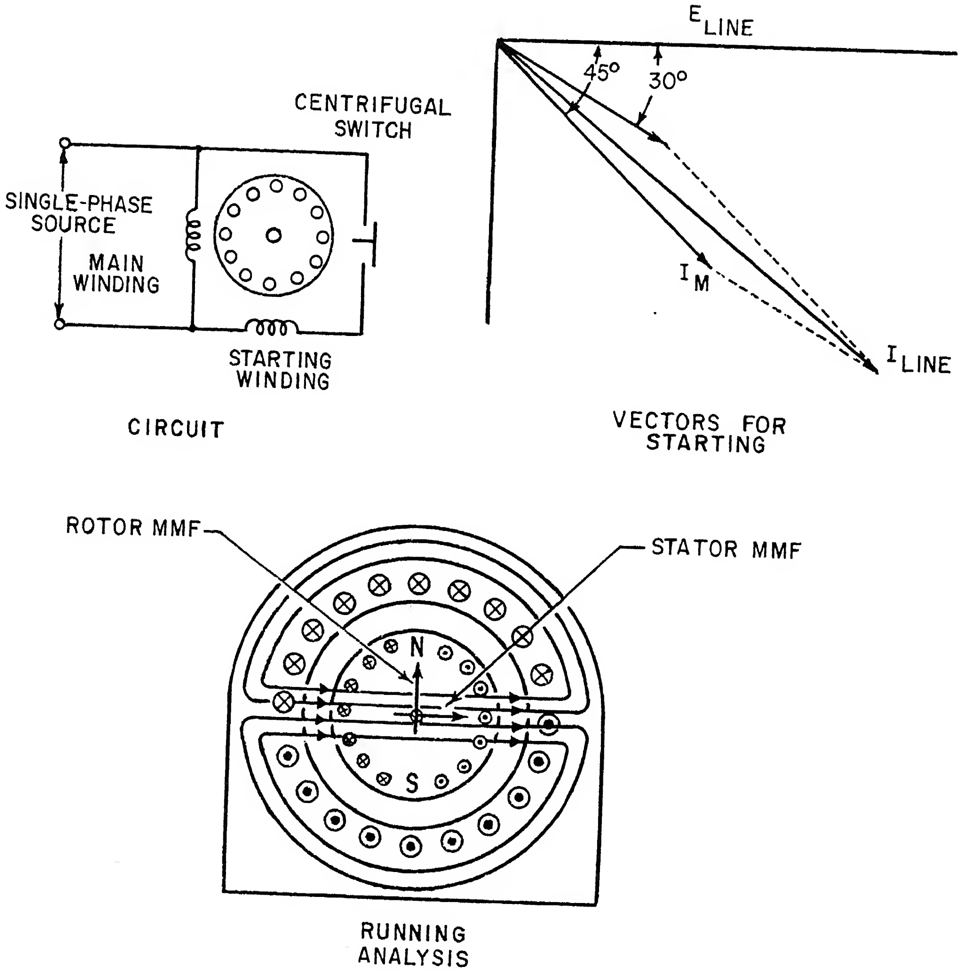


Figure 4-7.—Split-phase motor. 236.323

The stator field is assumed to be rotating at synchronous speed in a clockwise direction, and the stator currents correspond to the instant that the field is horizontal and extending from left to right across the airgap. The left-hand rule for magnetic polarity of the stator indicates that the stator currents will produce an N pole on the left side of the stator and an S pole on the right side. The motor indicated in figure 4-7C is wound for two poles.

CAPACITOR MOTOR

The capacitor motor is single-phase and has a capacitor in series with the starting winding. An external view is shown in figure 4-9 with the capacitor located on top of the motor. The capacitor produces a greater phase displacement of currents in the starting and running windings than is produced in the split-phase motor. The starting winding in the capacitor motor is made of many more turns of larger wire than that in the split-phase motor and is connected in series with the capacitor. The starting winding current is displaced approximately 90° from the running winding current. Since the axes of the two windings are also displaced by an angle of 90°, a higher starting torque is produced than that in the split-phase motor. The starting torque of the capacitor motor may be as much as 350 percent of the full-load torque.

If the starting winding is cut out after the motor has increased in speed, the motor is

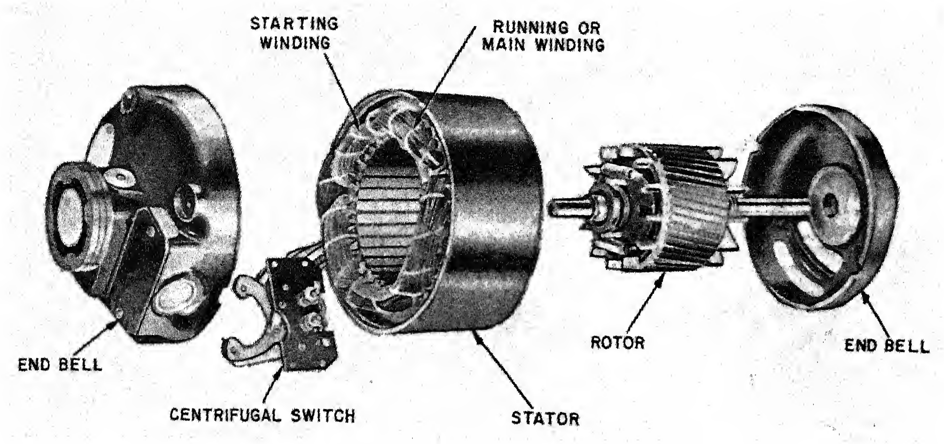


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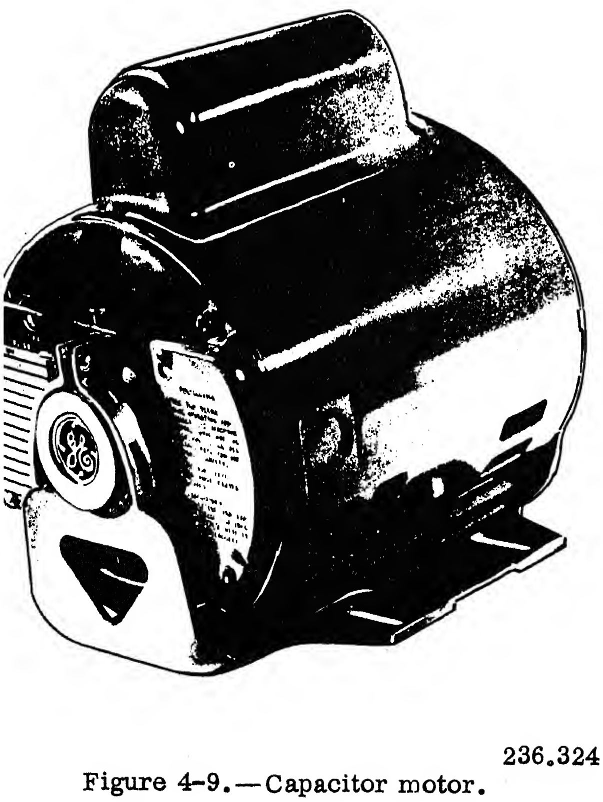
Figure 4-8.—Exploded view of a split-phase motor.

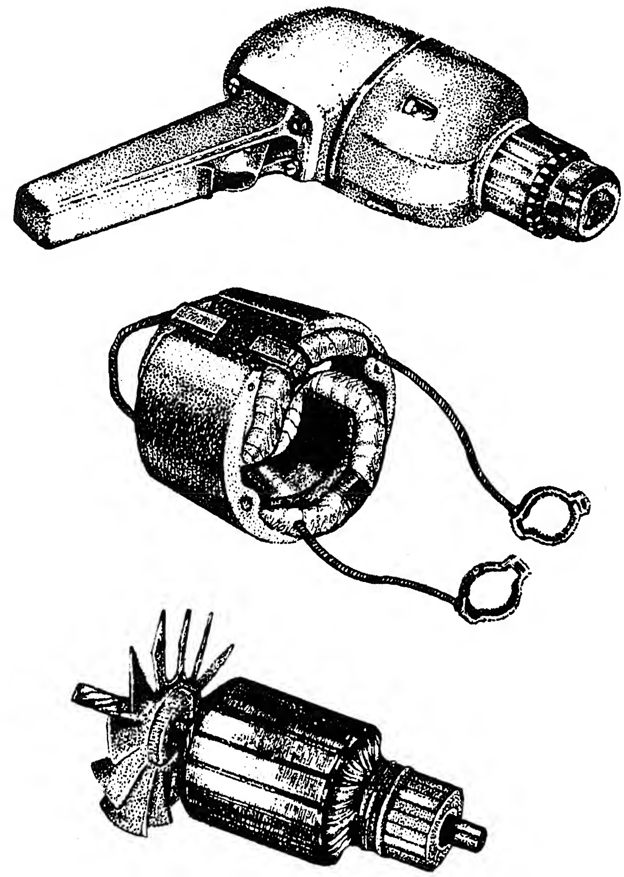


236.324
Figure 4-9.—Capacitor motor.

called a CAPACITOR-START MOTOR. If the starting winding and capacitor are designed to be left continuously in the circuit, the motor is called a CAPACITOR-RUN MOTOR. Electrolytic capacitors for capacitor-start motors vary in size from approximately 80 microfarads for 1/8-horsepower motors to 400 microfarads for 1-horsepower motors. Capacitor motors of both types are made in sizes ranging from small fractional horsepower motors up to approximately 10 horsepower. They are used to drive grinders, drill presses, refrigerator compressors, and other loads which require relatively high starting torque. The direction of rotation of the capacitor motor may be reversed by interchanging the starting and winding leads.

UNIVERSAL MOTOR

A universal motor (fig. 4-10) can be operated on either d.c. or single-phase a.c. Aboard Navy ships, they are used extensively for portable tools. The motor is constructed with a main field connected in series with an armature. The armature is similar in construction to any d.c. motor. When electric power is applied, the magnetic force created by the fields will react with the magnetic field in the armature and cause rotation.



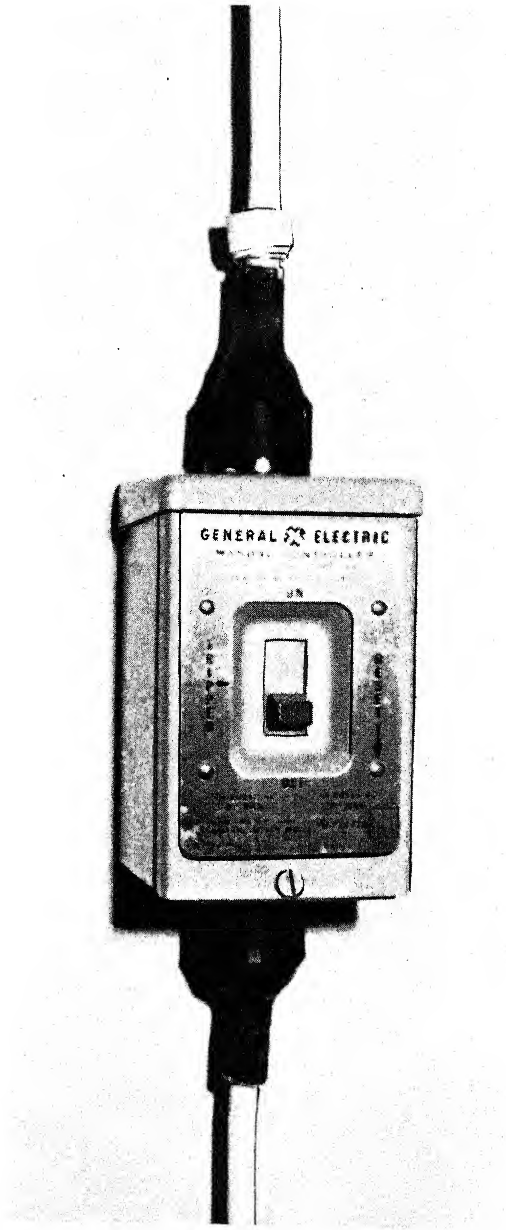
27.357
Figure 4-10.—Portable electric drill and universal motor parts.

CONTROLLERS

A controller is a device, or group of devices, which connects or disconnects the power supply to a motor. Most controllers also provide overload protection (overcurrent) for the motor. Some controllers are designed to reverse and select speeds on certain motors. Although controllers are designed in many different ways, we shall discuss only the basic fundamentals of controllers. You will find more detailed information in NAVSHIPS Technical Manual, Chapter 9630, EM 3 & 2, NAVEDTRA 10546-D, and the manufacturer's technical manual.

Controllers on naval vessels are either manual or magnetic for both a.c. or d.c.

A MANUAL or nonautomatic controller (fig. 4-11) is operated by hand directly through a mechanical system. The operator closes and opens the contacts that normally energize and de-energize the connected load. In a MAGNETIC



27.358
Figure 4-11.—Manual controller.

controller these contacts are closed and opened by electromechanical devices that are operated by local or remote master switches. Magnetic controllers may be semiautomatic or automatic.

DC CONTROLLERS

The starting of most d.c. motors, with the exception of fractional horsepower sizes, requires

a temporary insertion of resistance in series with the armature circuit to limit the high in-rush current at standstill. Because of this consideration, the starting resistance cannot be safely removed from the line until the motor has accelerated in speed and the counter electromotive force is of sufficient strength to limit the current to a safe value. This is normally accomplished with a d.c. controller (fig. 4-12).

The connections for a motor controller with one stage of acceleration is shown in figure 4-13. When the START button is pressed, the path for current is from line terminal L2 through the control fuse, STOP button, the closed START button, and the line contactor coil LC to line terminal L1. Current flowing through the contactor coil (LC) causes the contactor to pull in and close the line contacts, LC1, LC2, LC3, and LC4.

When contacts LC1 and LC2 close, motor-starting current flows through the series field SE, the motor armature A, the series relay

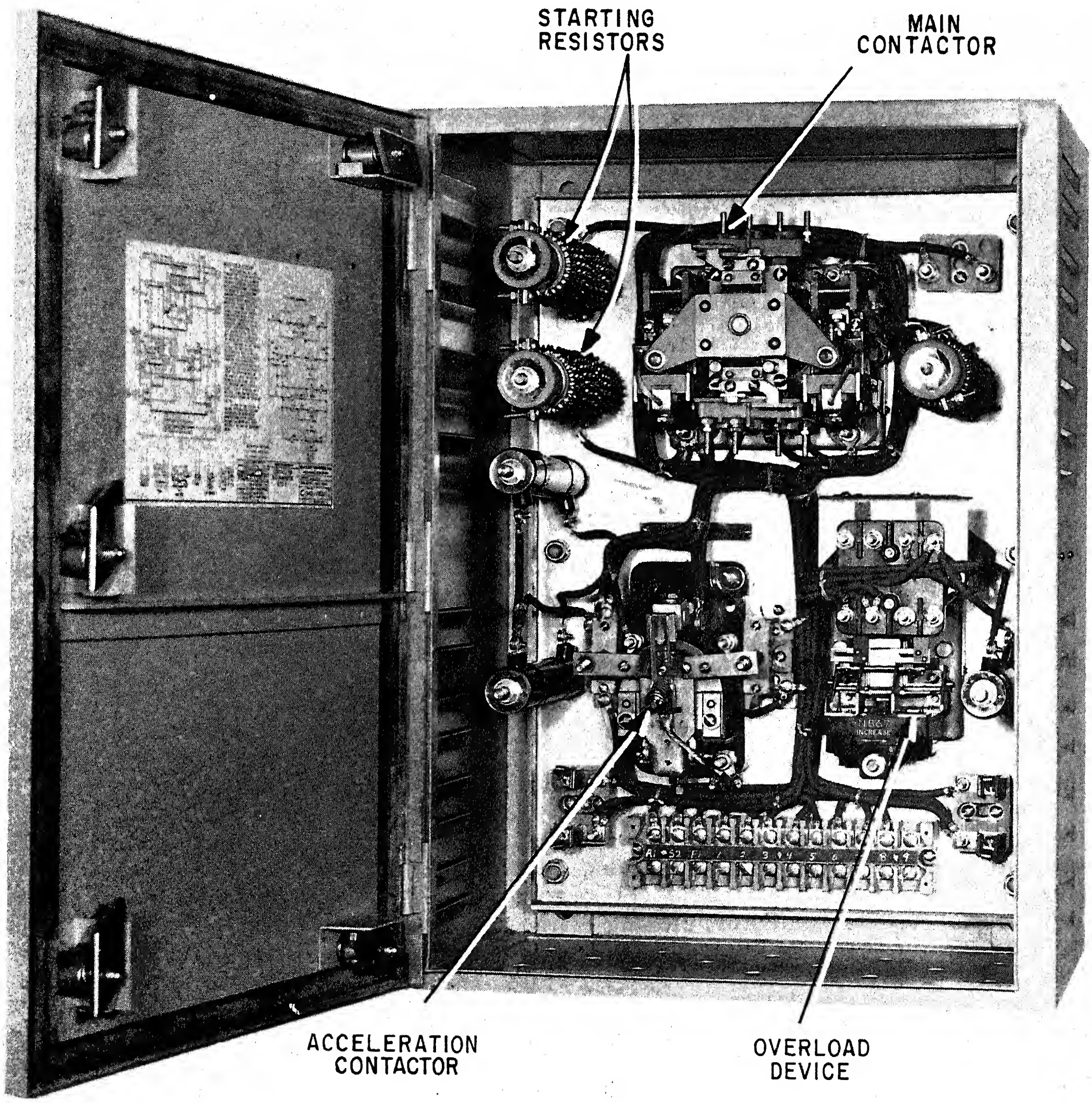


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Figure 4-12.—A typical d.c. controller.

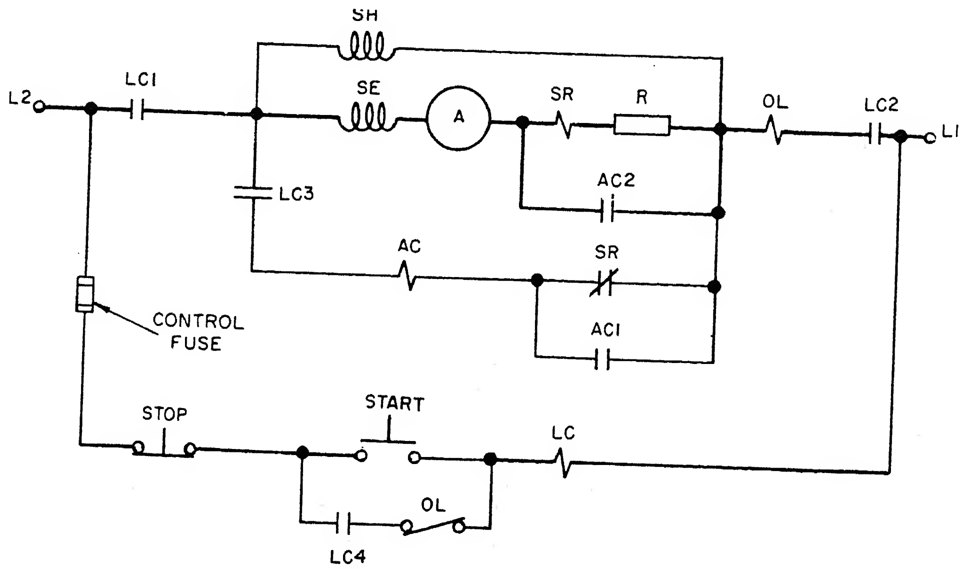

Figure 4-13.—D.c. controller with one stage of acceleration. 77.140

coil SR, the starting resistor R, and the overload relay coil OL. At the same time, the shunt field winding SH, is connected across the line and establishes normal shunt field strength. Contacts LC3 close and prepare the circuit for the accelerating contactor coil AC. Contacts LC4 close the holding circuit for the line contactor coil LC. The START button can now be released.

The motor armature current flowing through the series relay coil causes its contactor to pull in, thereby opening the normally closed contacts SR. As the motor speed picks up, the armature current drawn from the line decreases. At approximately 110 percent of normal running current, the series relay current is not enough to hold its contactor in; therefore, it drops out and closes its contacts SR. These contacts are in series with the accelerating relay coil AC, causing it to pick up its contactor, closing contacts AC1 and AC2.

Auxiliary contacts AC1 on the accelerating relay keep the circuit to the relay coil closed while the main contacts AC2 shunt out the starting resistor and the series relay coil. The motor is then connected directly across the line, and the connection will be maintained until the STOP button is pressed.

If the motor becomes overloaded, the excessive current through the overload coil (OL at the top right of fig. 4-13) will open the overload contacts (at the bottom of fig. 4-13) to disconnect the motor from the line.

If the main contactor drops out because of an excessive drop in line voltage or because of a power failure, the motor will remain disconnected from the line until an operator restarts it with the START pushbutton.

AC CONTROLLERS

Ac motors usually draw less power on starting, therefore starting resistance is not normally required on a.c. controllers. Most a.c. controllers are coupled to their power supply by across-line controllers. A typical 3-phase across-line controller consists of a 3-pole main-line contactor, two overload relays, mounting panel, an enclosure with mechanical overload-relay reset mechanism, and a master switch (start-stop pushbutton), as shown in figure 4-14. A schematic diagram of 3-phase a.c. across-the-line magnetic controller with overload and low voltage protection is shown in figure 4-15.

The motor is started by pushing the START button (fig. 4-15). This action completes the circuit from L3 through the control fuse, STOP

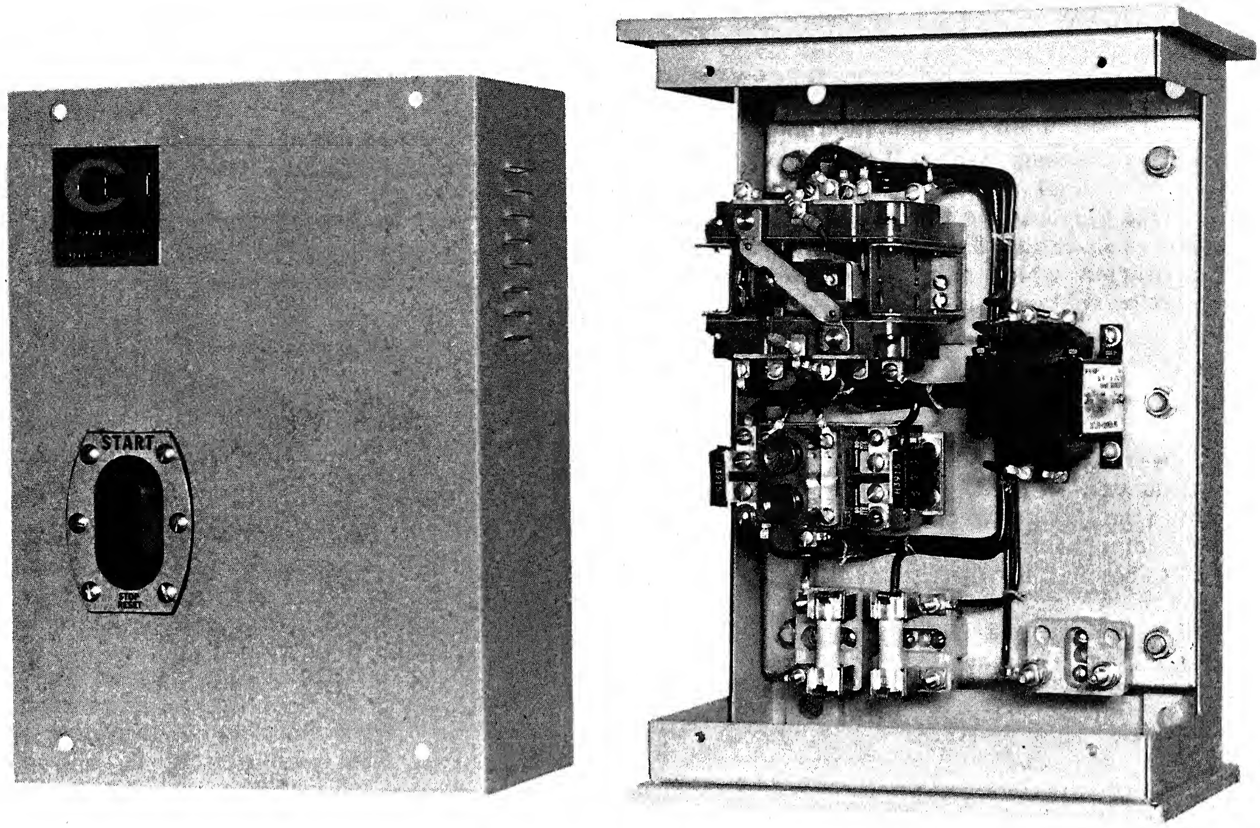

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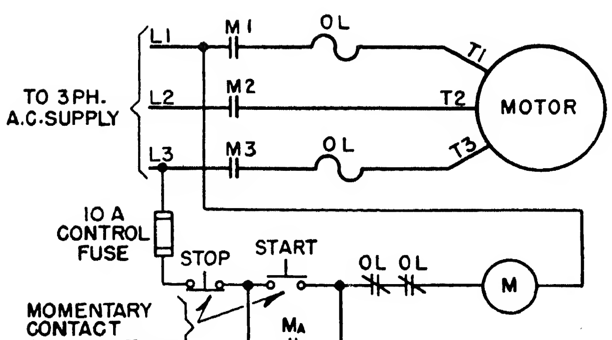
Figure 4-14.—Across-the-line, 3-phase, a.c. controller, pictoral view.



77.132
Figure 4-15.—A.c. controller with low voltage and overload protection, schematic diagram.

button, START button, the overload relay contacts OL, and the contactor coil M to L1. When the coil is energized, it closes line contacts M1, M2, and M3, which connect the full-line voltage to the motor. The line contactor auxiliary contact MA also closes and completes a holding circuit to maintain the M coil energized after the START pushbutton has been released.

The motor will continue to run until the contactor coil is deenergized by the STOP pushbutton, failure of the line voltage, or tripping of the overload relay OL. Some larger a.c. motors might require a limiting (controller) device in starting, which may be of the autotransformer type, the reactor controller type, or the primary resistor type,

Controllers are grouped under one of the following protective features: Low voltage protection, low voltage release, or low voltage release effect.

Low-Voltage Protection (LVP)

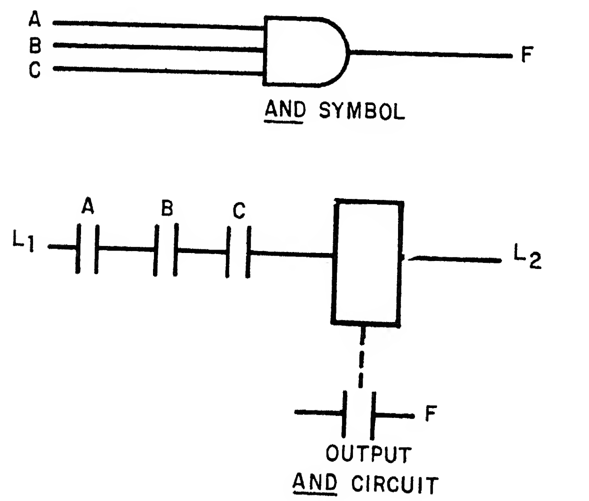
A low-voltage protection magnetic controller, upon loss or excessive reduction of supply voltage, disconnects the motor from the power supply and keeps it disconnected until the supply voltage returns to normal and the operator restarts the motor. This protects the power supply from overload upon restoration of power. LVP is desirable for auxiliaries which are not so essential that they must be restarted immediately.

Low-Voltage Release (LVR)

A low-voltage release magnetic controller, upon reduction or loss of supply voltage, disconnects the motor from the power supply, keeps it disconnected until the supply voltage returns to normal, and then automatically restarts the motor. Controllers with this feature are used only for auxiliaries which must be restarted immediately upon restoration of power.

Low-Voltage Release Effect (LVRE)

A low-voltage release effect controller provides the same effect in manual controllers as is obtainable in a low-voltage release type magnetic controller. That is, it will restart automatically upon restoration of power.



77.356
Figure 4-16.—AND symbol and circuit.

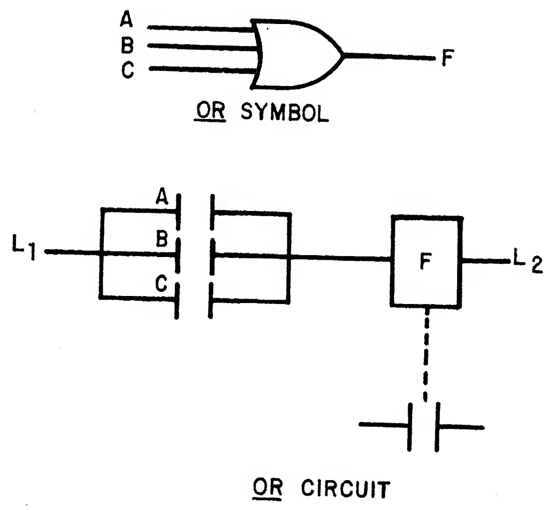


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Figure 4-17.—OR symbol and circuit.

LOGIC CONTROLLERS

All control circuits employ logic. The basic electrical controls use electrical and mechanical devices to perform their logic. In figure 4-16A you can see that contacts a, b, and c must ALL be closed to energize the relay, thereby creating an output. The same transistor circuit switch (electronic switch) can be used and is represented by the logic symbol (AND) shown in figure 4-16B.

Another electrical circuit is shown in figure 4-17A. As you can see, EITHER a or b contact can be closed thus energizing the relay and obtaining an output. The comparable logic symbol (OR) is shown in figure 4-17B.

Using the characteristics of the AND and OR logic symbols we shall discuss how they can be used in a logic controller.

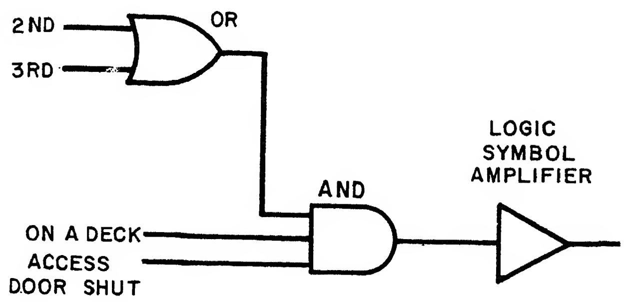

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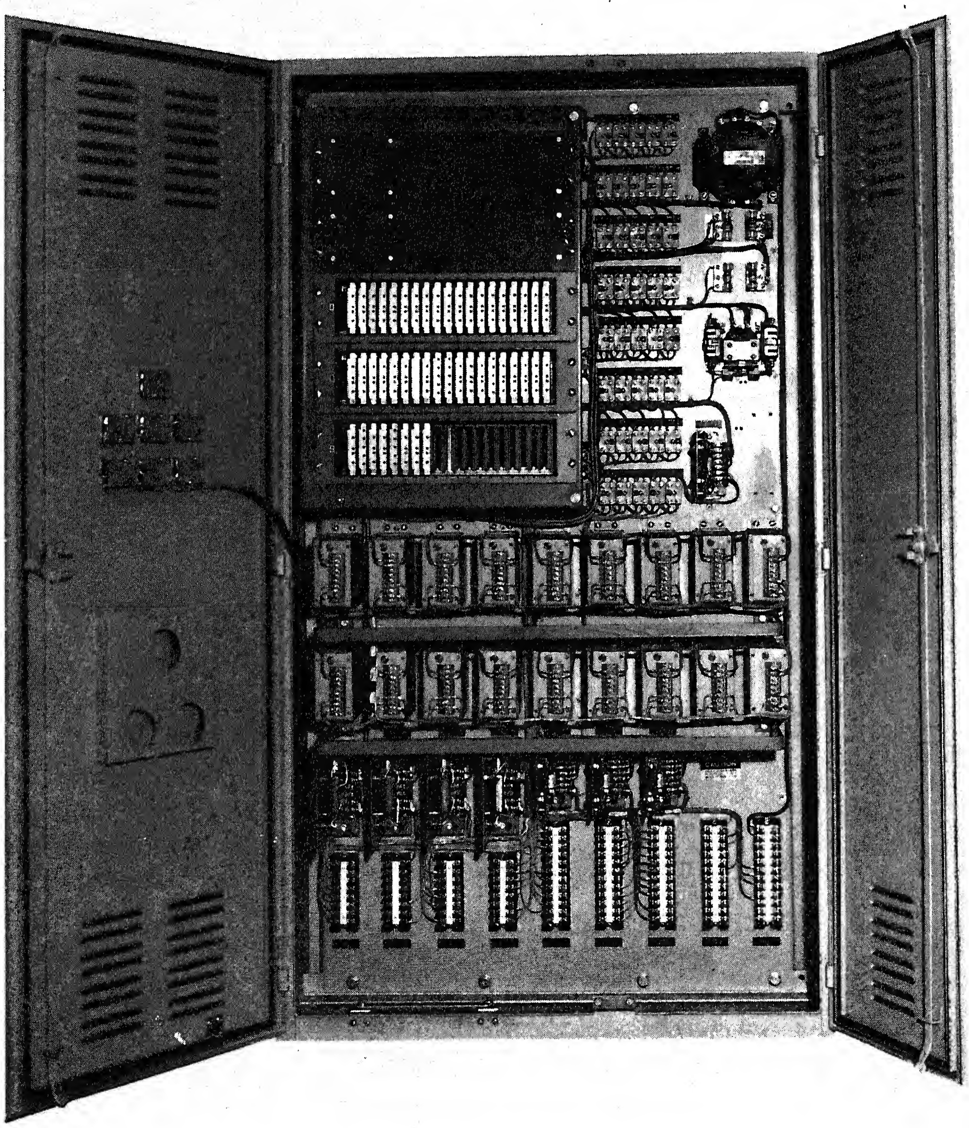
Figure 4-18.—Basic logic circuit.

One common application of logic control that is being incorporated on newer ships is the elevator system. Since this system is large with many symbols, we shall show only a small portion.

Let us assume that the elevator platform is on the third deck and that you require it on the main deck. Refer to figure 4-18. Three conditions must be met before the elevator can be safely moved. These conditions are detected by electronic sensors usually associated with the driven component. One of the conditions is that the platform must be on EITHER the second or third deck (on a certain deck as opposed to somewhere in between). If this condition is sensed, the OR symbol will have an input, and since only one input is needed, the OR symbol will also have an output.

The other conditions to be met are that the locking devices must be engaged and the access doors must be shut. If the sensors are energized for these two conditions, the AND symbol



77.290

Figure 4-19.—A static logic panel for a cargo elevator.

will have the three inputs necessary to produce an output. This output will then set up a starting circuit allowing the motor to be started at your final command.

The advantages of these electronic switches over mechanical switches are low power consumption, no moving parts, less maintenance, quicker response, and less space requirement A typical static logic panel found aboard sh is shown in figure 4-19.

Although there are logic symbols other th AND and OR, they all incorporate solid sta devices. More information can be found in Ele trician's Mate 3 & 2, NAVEDTRA 10546-D.

CHAPTER 5

SHIPBOARD LIGHTING

The lighting aboard ship is one of the most important systems and, many times, one of the most neglected. Several factors contribute to this seeming paradox—maintenance in progress on other systems, constant illumination in some spaces, jury rigs, unauthorized changes, etc.

Because of the continuous and unusual demands on shipboard lighting systems, a vigorous program of preventive and corrective maintenance must be established and maintained. The most important feature of such a program is the protection of personnel and equipment against electrical hazards. We cannot stress enough: ALL SAFETY PRECAUTIONS MUST BE CAREFULLY OBSERVED.

We shall discuss light sources that produce general ambient illumination, as well as special lighting applications. You will find more information on lighting systems and safety precautions in NAVSHIPS Technical Manual, chapter 9600; Electric Shock—Its Cause and Its Prevention, NAVSHIPS 250-660-42; and Lighting on Naval Ships, NAVSEA 0964-000-2000.

LIGHT SOURCES

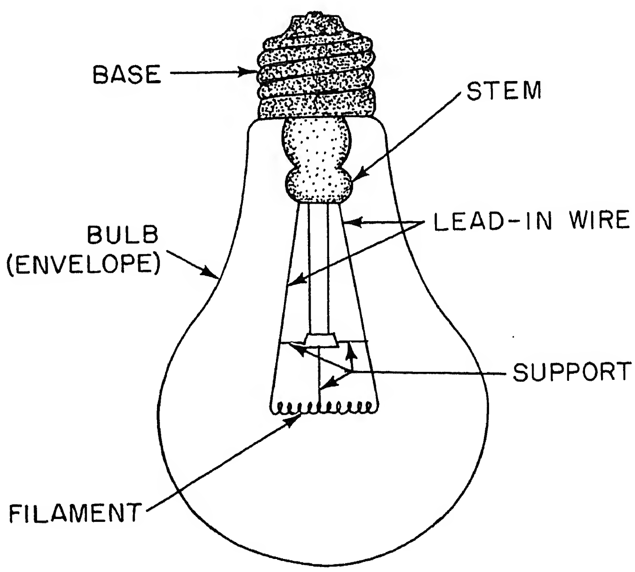
The primary purpose of a light source is simply to produce light. The most common sources of electric light used aboard naval ships are the (1) incandescent, (2) fluorescent, and (3) glow lamps. There is a complete listing of the lamps used by the Navy in federal item identification number sequence in the Illustrated Shipboard Shopping Guide (ISSG) FSC 6240. This listing is carried aboard all ships and includes the electrical characteristics, physical dimensions, and an outline of each Navy type lamp.

INCANDESCENT LAMPS

Incandescent lamps produce light by means of a tungsten or carbon filament which is heated to incandescense by an electric current. Oxidation with its attendant failure is prevented by surrounding the filament with an inert gas or by operating it in a vacuum. Most incandescent lamps used for shipboard lighting are 115-120 volts, 25-200 watt, inside frosted, rough service (RS) lamps. RS lamps (fig. 5-1) have specially constructed filaments supported at several points to increase their ability to withstand shock. The frosting conceals the filament and diffuses the light emitted from the lamp. These lamps may be used with or without reflecting equipment.

DESIGNATION

Standard incandescent lamps are designated according to the (1) shape of bulb, (2) the finish of bulb, (3) the type of base, and (4) the size of the base.



12.359

Figure 5-1.—Components of an incandescent lamp.

The shape of the bulb is identified by a corresponding letter designation, as illustrated in figure 5-2A. The designation letter is followed by a numeral (not shown) that denotes the diameter of the bulb in eighths of an inch.

The designation of lamps according to the type of base is illustrated in figure 5-2B. The size of the base is indicated by name — mogul, candelabra, intermediate, etc. Each type of base is provided in different sizes. The types are also denoted by name — bayonet, prefocus, bipost, etc.

Most lamps aboard ship are of the frosted finish type to help eliminate the glare of the filament.

CHARACTERISTICS

The average life of standard lamps for general lighting service, when operated at rated voltage, is 750 hours for some sizes and 1000 hours for others. The light output, life, and electrical characteristics of a lamp are materially affected when it is operated at other than the design voltage. Operating a lamp at less than rated voltage will prolong the life of the lamp but will decrease the light output. Conversely, operating a lamp at a higher than rated voltage will shorten the life but will increase the light output. Lamps should be operated as closely as possible to their rated voltage.

FLUORESCENT LAMPS

Fluorescent lamps are now used for the majority of lighting aboard naval ships. They consume less power with greater illumination and therefore are more efficient than incandescent lamps.

Construction

The fluorescent lamp is an electric discharge lamp that consists of an elongated tubular bulb with an oxide-coated filament sealed into each end to contain two electrodes. The bulb contains a drop of mercury and a small amount of argon gas. The inside surface of the bulb is coated with a fluorescent phosphor. The lamp produces invisible, shortwave (ultraviolet) radiation by discharging current through the mercury vapor in the bulb. The phosphor absorbs the invisible radiant energy and reradiates it over a band of wavelengths to which the eye is sensitive.

The Navy has standardized on three lamp sizes: 8 watts, 15 watts, and 20 watts. The use of fluorescent lamps of more than 20 watts is limited to special installations.

Operation

Fluorescent lamps installed aboard ship are of the hot-cathode, preheat starting type. A fluorescent lamp equipped with a glow-switch starter is illustrated in figure 5-3. The glow-starter is essentially a glow lamp containing neon or argon gas and two metallic electrodes. One electrode has a fixed contact, and the other electrode is a U-shaped, bimetal strip having a movable contact. These contacts are normally open.

When the circuit switch is closed, there is practically no voltage drop across the ballast, and the voltage across the starter (S) is sufficient to produce a glow around the bimetallic strip in the glow lamp. The heat from the glow causes the bimetal strip to distort and touch the fixed electrode. This action shorts out the glow discharge and the bimetal strip starts to cool as the starting circuit of the fluorescent lamp is completed. The starting current flows through the lamp filament in each end of the fluorescent tube, causing the mercury to vaporize. Current does not flow across the lamp between the electrodes at this time because the path is short circuited by the starter and because the gas in the bulb is nonconducting when the electrodes are cold. The preheating of the fluorescent tube continues until the bimetal strip in the starter cools sufficiently to open the starting circuit.

When the starting circuit opens, the decrease of current in the ballast produces an induced voltage across the lamp electrodes. The magnitude of this voltage is sufficient to ionize the mercury vapor and start the lamp. The resulting glow discharge (arc) through the fluorescent lamp produces a large amount of ultraviolet radiation that impinges on the phosphor, causing it to fluoresce and emit a relatively bright light. During normal operation the voltage across the fluorescent lamp is not sufficient to produce a glow in the starter. Hence, the contacts remain open and the starter consumes no energy.

Characteristics

As temperature increases above normal, the efficiency of fluorescent lamps decreases slowly, and as the temperature decreases below normal, efficiency decreases very rapidly. Hence, the fluorescent lamp is not satisfactory for locations in which it will be subjected to wide variations in temperature.

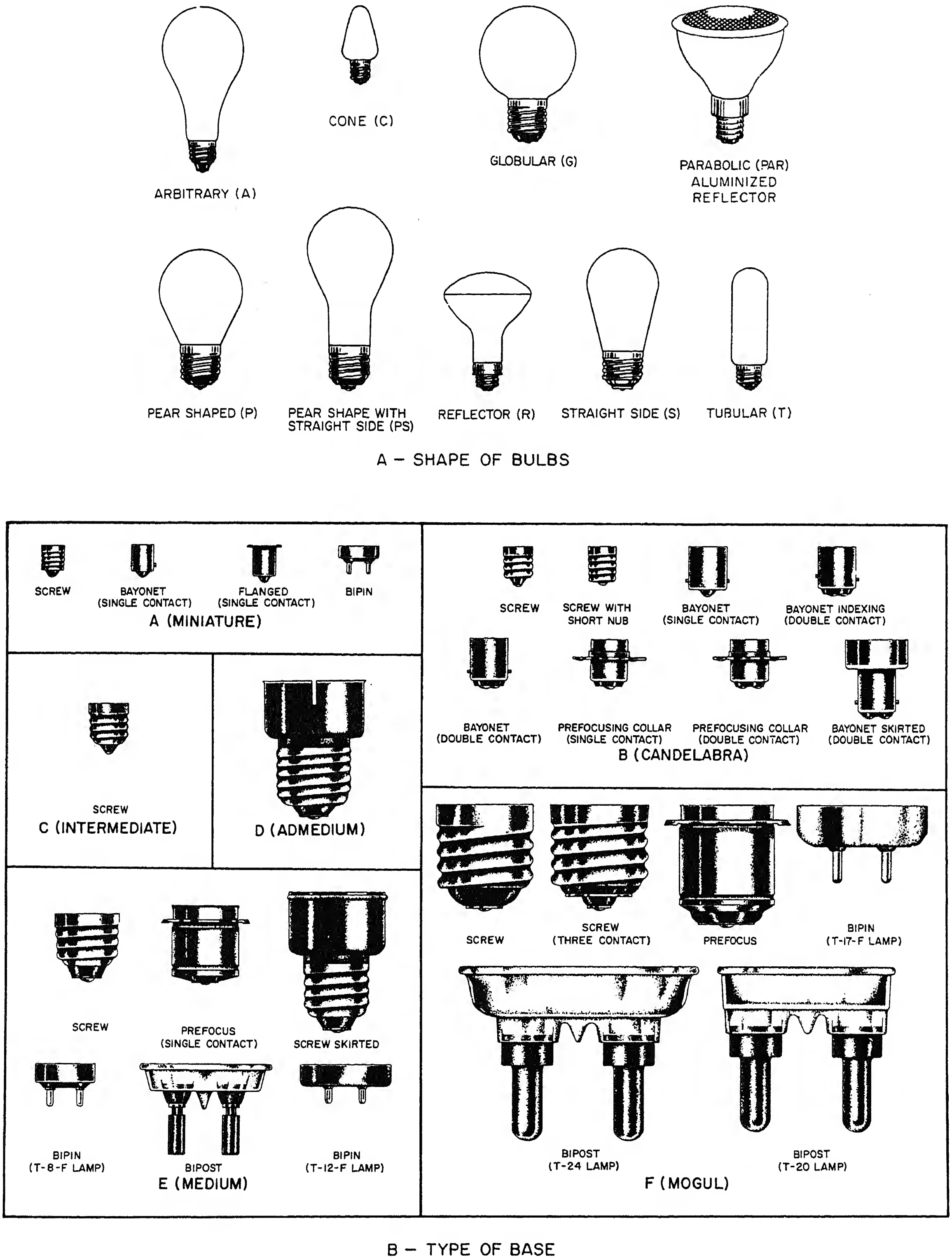


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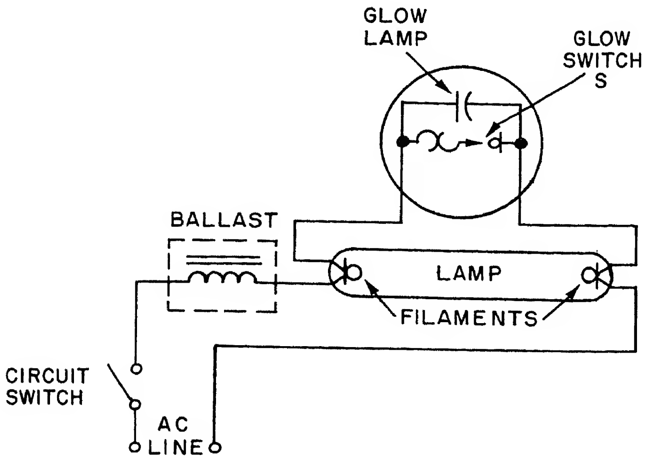
Figure 5-2.—Classification of lamps.



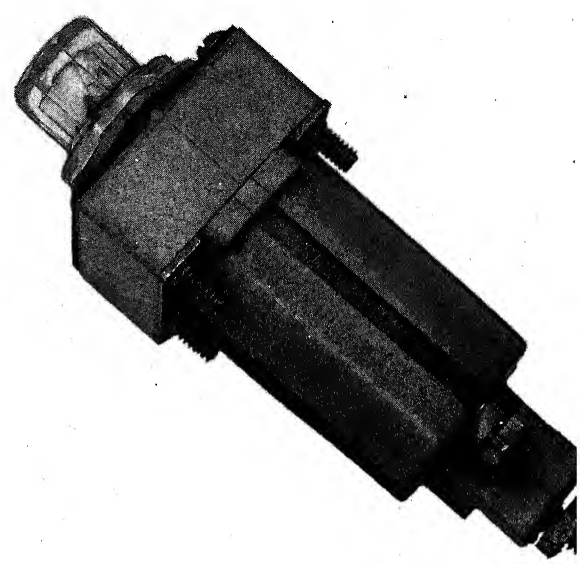
27.360
Figure 5-3.—Glow-switch starter and fluorescent lamp.

Fluorescent lamps should be operated at voltage within ±10% of their rated voltage. If the lamps are operated at lower voltages, uncertain starting may result, and if operated at higher voltages, the ballast may overheat. Operation of the lamps at either lower or higher voltages results in decreased lamp life. The performance of fluorescent lamps depends to a great extent on the characteristics of the ballast, which determines the power delivered to the lamp for a given line voltage.

The failure of a hot-cathode fluorescent lamp usually results from loss of electron-emissive material from the electrodes. This loss proceeds gradually throughout the life of the lamp and is accelerated by frequent starting. Blackening of the ends of the bulb progresses gradually throughout the life of the lamp.

GLOW LAMPS

Glow lamps are electric-discharge light sources which are used as indicator or pilot lights on various instruments, fuseholders, and control panels (fig. 5-4). Since glow lamps have a relatively low light output, they are used to indicate the energizing of circuits or the operation of electrical equipment in remote locations, rather than for illumination. These lamps offer the advantages of small size, ruggedness, long life, low power consumption, and operation in standard lighting circuits.



1.40
Figure 5-4.— Fuse holder with glow lamp.

The glow lamp consists of two closely spac metallic electrodes sealed in a glass bulb t contains an inert gas. The color of the li emitted by the lamp depends on the gas. Ne gas produces an orange-red light, and arg gas produces a blue light. The lamp must operated in series with a current-limiting dev to stabilize the discharge. The current-limit device consists of a high resistance that sometimes contained in the lamp base.

The glow lamp produces light only when voltage exceeds a certain striking voltage. the voltage is decreased below this value, glow suddenly vanishes. When the lamp is opera on alternating current, light is produced o during a portion of each half-cycle and b electrodes are alternately surrounded with a glc When the lamp is operated on direct curre light is produced continuously, and only negative electrode is surrounded with a glow. Tl characteristic makes it possible to use the gl lamp as an indicator of both alternating curr and direct current.

LIGHTING FIXTURES

A lighting fixture is a device that hous the lighting source (lamp). It acts to prov

satisfactory illumination while reducing glare and affording protection to the lamp from mechanical and battle damage. Lighting fixtures are manufactured for incandescent (fig. 5-5A and B) or fluorescent (fig. 5-5C and D).

Permanent fixtures (incandescent or fluorescent) are permanently installed to provide general illumination and such detail illumination as may be required in specific locations. GENERAL ILLUMINATION is based on the light intensity required for the performance of normal routine duties. DETAIL ILLUMINATION is provided where the general illumination is inadequate for the performance of specific tasks. Sources include berth fixtures, desk lamps, and plotting lamps.

Portable fixtures are provided for lighting applications that cannot be served by permanently installed fixtures. These units are energized by means of portable cables that are plugged into outlets in the ship's service wiring system and include bedside lights, desk lights, floodlights and extension lights.

TRANSFORMERS

An understanding of transformers will help you follow the discussion on lighting systems.

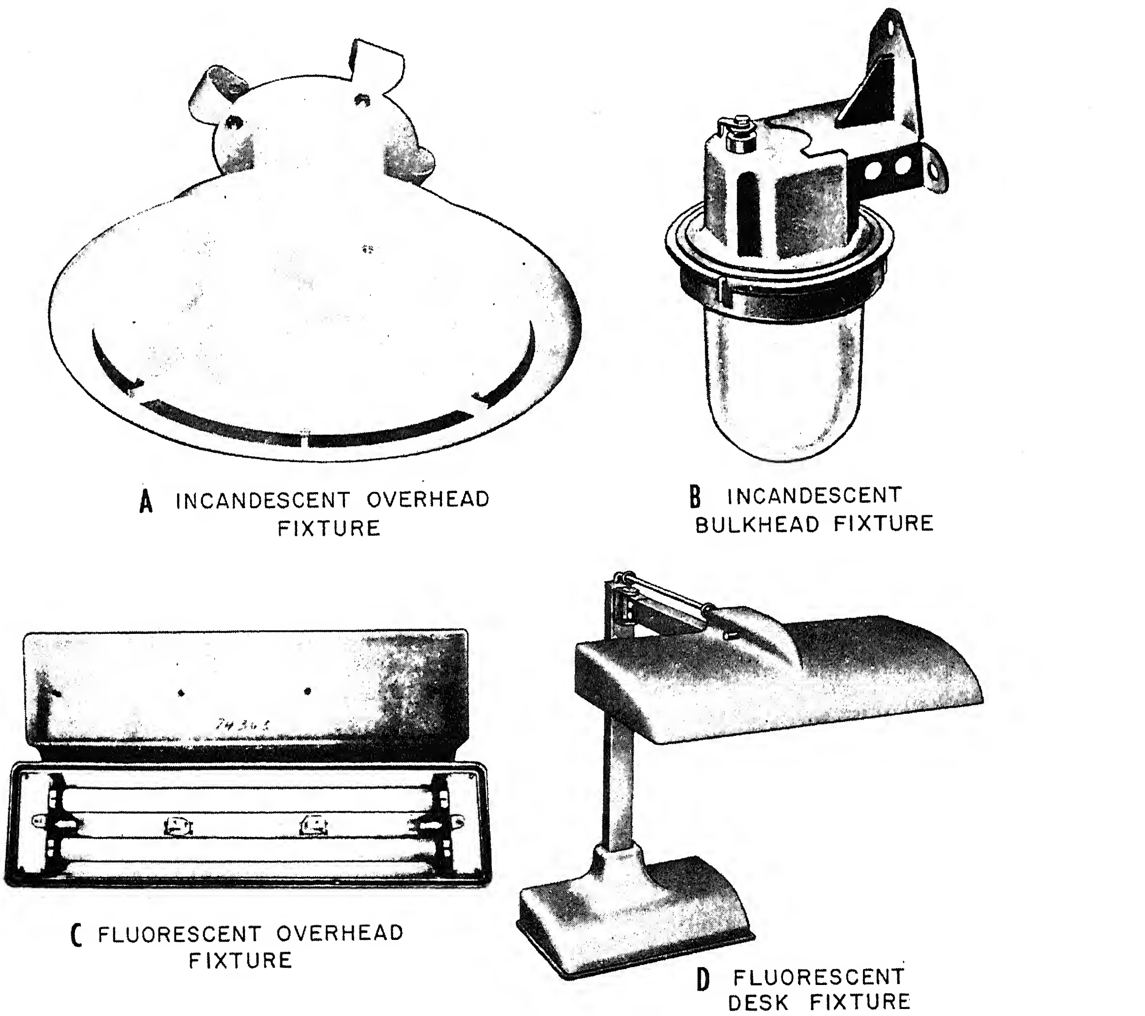


Figure 5-5.—Lighting fixtures.

Basically, transformers work on the same principles as the a.c. induction motor described in chapter 4. That is, the primary winding (450 VAC) receives power from the ship's service supply. The secondary winding (120 VAC) produces a voltage due to the expanding and collapsing magnetic field of the primary. This induced voltage in the secondary is lower than the primary due to the winding turns ratio. This type transformer is called a step-down transformer because of the lower voltage in the secondary. Similar to the a.c. induction motor, there are no electrical connections between the primary and secondary windings.

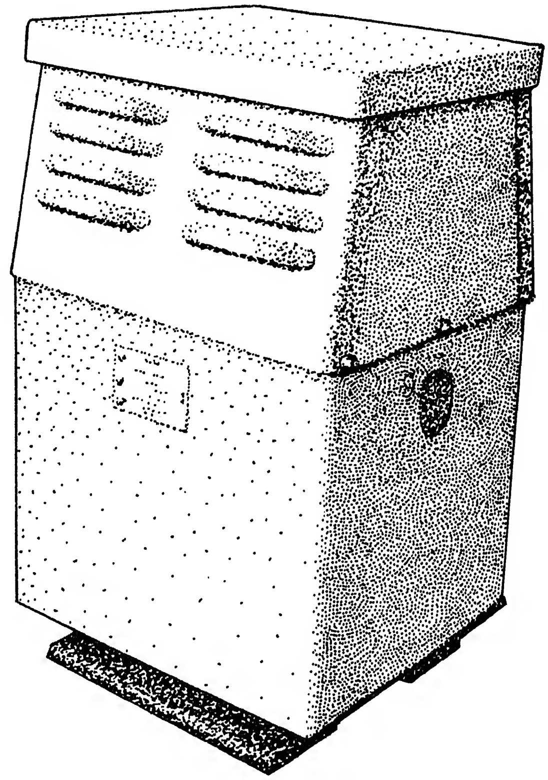
LIGHTING SYSTEMS

The lighting distribution system in naval vessels is designed for satisfactory illumination, optimum operational economy, maximum continuity of service, and minimum vulnerability to mechanical and battle damage. Most ships have two sources of power supply for lighting fixtures. Normal supply is from the ship's service bus. A designated number of fixtures can also be supplied from the emergency distribution system. Additionally, there is a third lighting system that consists of battery-powered, relay-operated, hand lanterns.

The first two systems consist of feeders from the ship's service or emergency power switchboards, switchgear groups, or load centers to distribution panels or feeder distribution fuse boxes, located at central distribution points from which power is distributed to the local lighting circuits.

The a.c. ship's service power feeders are normally 450-volt, 3-phase, 60-hertz circuits. The lighting supply circuits are 450-volt, 3-phase, 60-hertz, 3-wire circuits supplied from the power distribution system to 450/120-volt transformer banks.

Three small transformers are used instead of one large transformer because the loss of a single composite unit would result in a total loss of power. By using three separate transformers, reliability is increased. In the event of an enemy hit or failure of one of the bank of three single-phase transformers (fig. 5-6), the remaining two will still carry approximately 58 percent of the initial bank capacity. The line current must be sufficiently reduced to sta within the limits of the rated current of th two remaining transformers.



236.3
Figure 5-6. — Single-phase transformer.

A typical vital lighting load has access t two switchboards (fig. 5-7). Selection of eithe of these sources is automatic through an auto matic bus transfer (ABT) switch. Additionally the emergency switchboard has three powe supplies that are independent of each othe As a result of this arrangement, the vital lightin load can be automatically supplied from severa primary sources.

The system shown in figure 5-7 operates a follows. If an undervoltage condition develop on switchboard 2SA, which is the normal suppl for ABT switch #1, the ABT switch will transfe the lighting load center panel to the emergenc lighting load center panel whose power sourc is emergency switchboard 2E.

Emergency switchboard 2E is energized eithe from its normal or alternate ship's servic supply feeders, or from the local emergenc

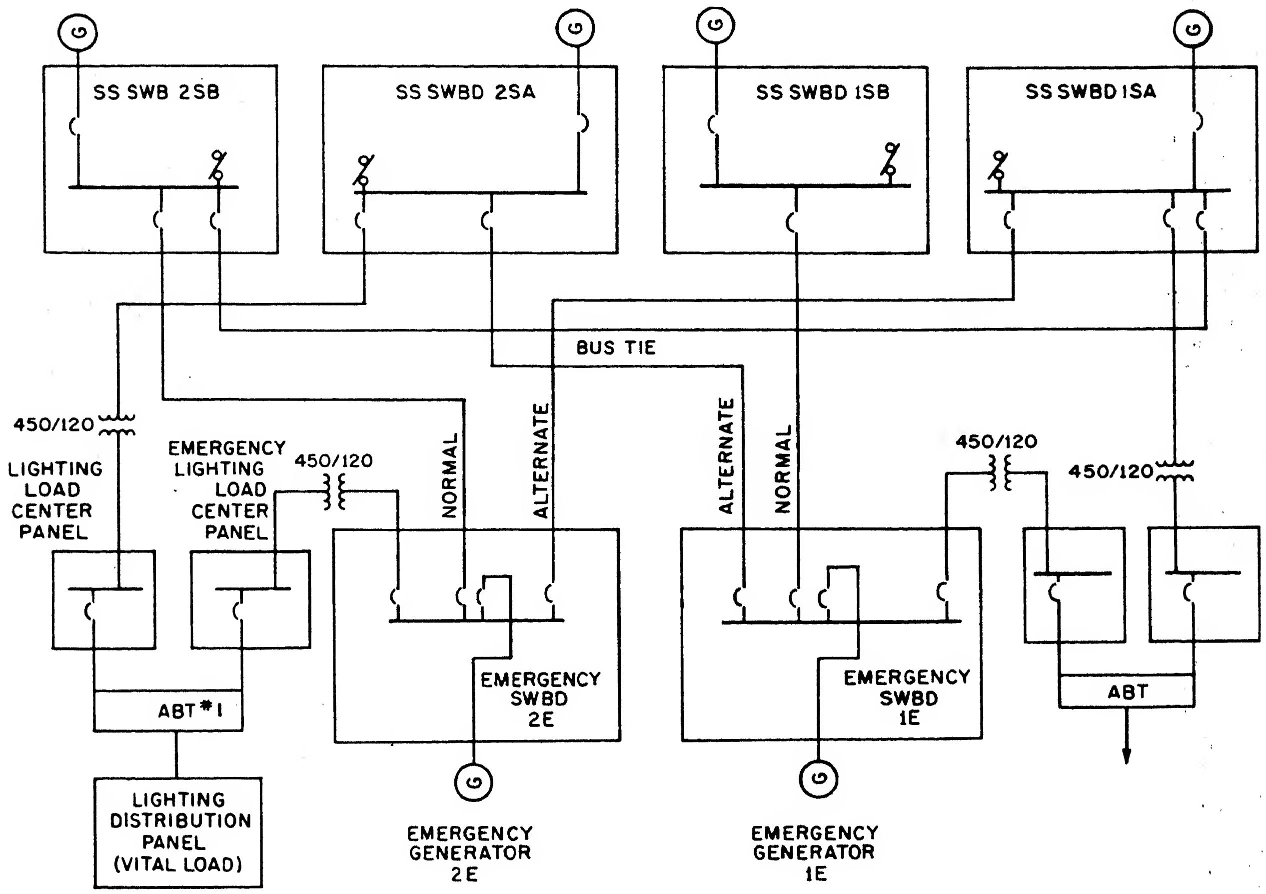


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Figure 5-7.—Typical lighting distribution system.

generator. Transfer between these supplies is automatic by three electrically operated circuit breakers. The circuit breakers are electrically and mechanically interlocked to prevent closing of more than one breaker at a time. Normally, the emergency switchboard is energized from one of the two ship's service supplies. If voltage on the normal ship's service supply bus drops to 300 volts, or below, the load automatically transfers to the alternate supply if 400 volts or above is available at that source. (If 400 volts or above is restored to the normal supply, the load will automatically retransfer to the normal supply.) If both ship's service supplies fail completely or if their voltage drops to 300 volts, the transfer system will operate automatically to start the emergency generator and connect it to the emergency switchboard.

DARKENED SHIP EQUIPMENT

Darkened ship is a security condition designed to prevent the exposure of light, which could reveal the location of the vessel. Darkened-ship condition is achieved by means of (1) light traps that prevent the escape of light from illuminated spaces, or (2) door switches that automatically disconnect the lights when the doors are opened.

A light trap is an arrangement of screens placed inside access doors or hatches to prevent the escape of direct or reflected light from within (fig. 5-8). The inside surfaces of the screens are painted flat black so that they will reflect a minimum of light falling on them. Light traps that are used to prevent the escape

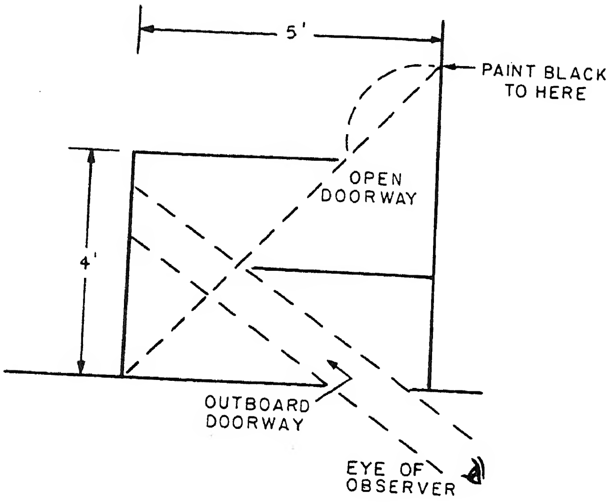

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Figure 5-8.— Light trap.

of white light should have at least two black, light-absorbing surfaces interposed between the light source and the outboard openings. Light traps are preferred to door switches in locations where (1) exit and entrance are frequent; (2) interruption of light would cause work stoppage in large areas; (3) light might be exposed from a series of hatches, one above the other on successive deck levels; and (4) where many small compartments and passages are joined by numerous inside and outside doors that would complicate a door-switch installation.

A door switch is mounted on the break side of a door jamb (inside the compartment) and operated by a stud welded to the door. When the door is opened, the switch automatically opens at the same time. Door switches are connected in a variety of ways to suit the arrangement of the compartment concerned.

All door switch installations are provided with lock-in devices or short-circuiting switches to change the settings of the door switches, as required from lighted ship to darkened ship, and vice versa.

RED ILLUMINATION

When a person leaves a well-lighted space and enters a dimly lighted space, his vision is impaired until his eyes become accustomed to the dark. When he can again see, his eyes are said to be dark adapted. For personnel having battle stations or watch stations topside, this time interval could be detrimental to his ability to stand his watch. The primary purpose of red illumination is to provide low-level illumination access routes to dimly lighted areas with minimum interference to dark-adapted vision.

Red illumination is accomplished by using standard red light fixtures or red filters over standard white lights.

BLUE ILLUMINATION

A unique problem arises in the illumination of spaces that contain radar system display consoles. Normal lighting (standard white light) excites the phosphor coating on the inside of the cathode ray tube (CRT). This results in a dimming of the target trace, thereby affecting the operator's ability to see the target.

The conventional solution for years was to darken the room. This improved the CRT display but hindered other important ongoing operations in the room, such as reading charts and messages, plotting on status boards, and PMS requirements.

A solution to the problem was found by using blue illumination. The basic principle of this lighting system is frequency sharing. A broad band of blue light is allocated for ambient illumination, and the remaining portion of the visible spectrum is used for CRT viewing. The system is referred to as Broad Band Blue (BBB) lighting.

White light contains all the colors of the visible spectrum, therefore, any ambient illumination has some white light. By using two filters we can almost eliminate the white light to the CRT.

A blue filter is placed over the fluorescent fixtures (fig. 5-9) which allows only the desired wavelengths to pass, leaving enough ambient illumination but decreasing the white available to interfere with the CRT.

A second filter, amber, which will not pass the wavelengths of the blue light but will allow the CRT signal to be seen, is placed over the CRT.

The combination of blue and amber filters provides improved scope visibility with an illuminated working environment.

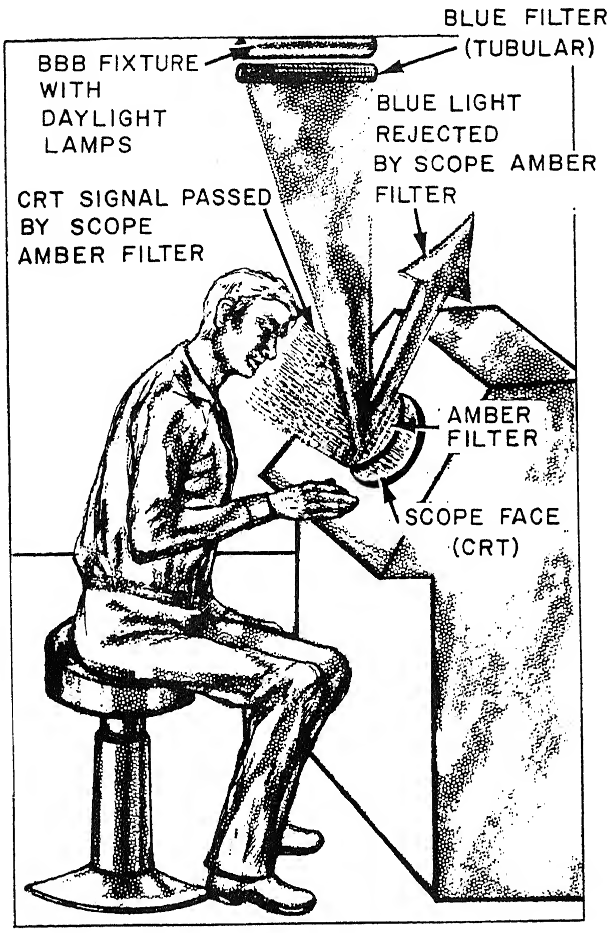

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Figure 5-9.—BBB lighting system.

SPECIAL LIGHTING APPLICATIONS

Up to this point we have limited our discussion of shipboard lighting to general ambient illumination. In the next portion of this chapter we shall describe different lights and fixtures not generally associated with compartment illumination.

REPLENISHMENT-AT-SEA RED LIGHTING

To enable extended periods of operations at sea, units of the fleet receive the logistic support they require by means of replenishment-at-sea (RAS) operations.

In the past most RAS operations were conducted during daylight hours because of visibility considerations. With increased demands for night operations the need for night RAS became increasingly important. RAS lighting (fig. 5-10) permits night replenishment with minimum risk to the safety of both ships and personnel.

Hull Contour Lights

Hull contour lights (fig. 5-10) consist of three red 25-watt lights shown by the control (replenishment) ship during the approach and while the receiving ship is alongside. These lights are located at the fore and aft extremes of that portion of the side parallel with the keel.

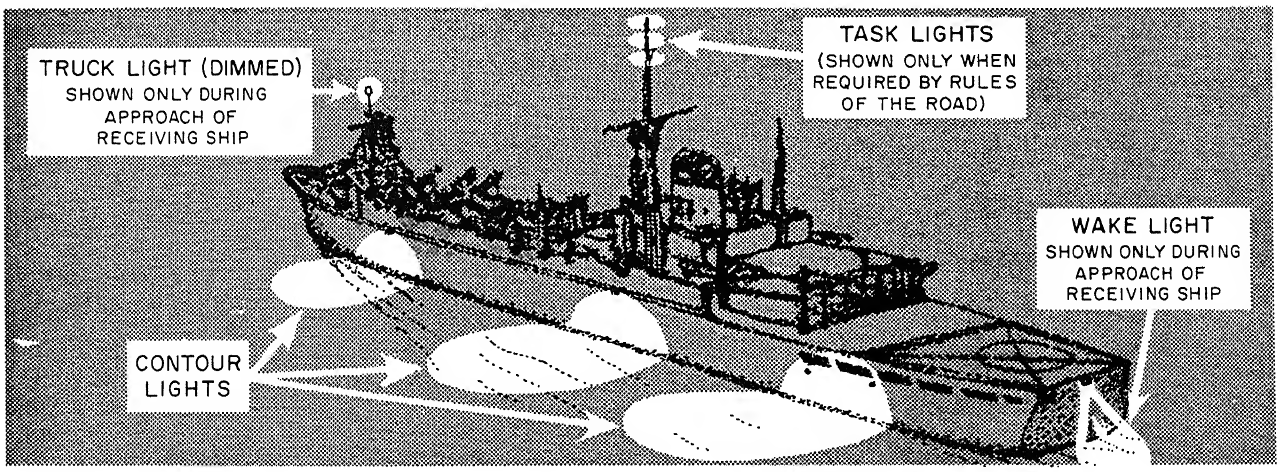


Figure 5-10.—RAS lighting. 27.362

Obstruction Lights

The obstruction lights indicate to the control ship items which may interfere with the cargo as it approaches the receiving ship, such as deck edges, missile launches, etc. Six one-cell, red-lens, pin-on-type flashlights (fig. 5-11A) or six chemical lights (fig. 5-11B) are attached in a straight line to a 6-inch wide, 12-foot long strip of white canvas, which is placed along the deck edge or along other obstructions outb of the receiving ship.

Station Marker Light Box

A portable light box (fig. 5-12) is loc at the replenishment station of both the con and approach ships. It uses a code (table 5 to indicate the commodity being transferr

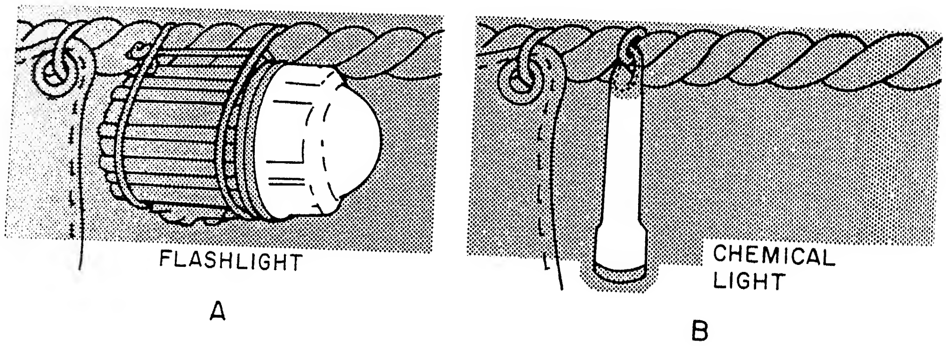


Figure 5-11. — One-cell flashlight and chemical light (obstruction lights). 27.36

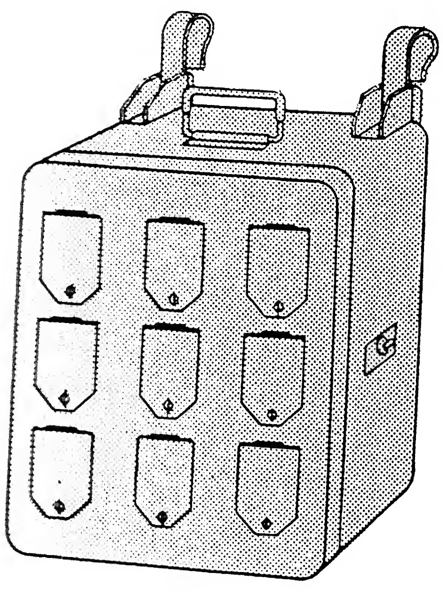


Figure 5-12. — Station marking light box. 27.364

Phone/Distance Line Marking

The phone/distance line is hung between the two ships to indicate the distance between them and can be used to hold sound-powered telephone cable. A single chemical light is attached at every 20-foot interval along the phone/distance line. A cluster of three chemical lights is interspersed along the line at 60-, 100-, and 140-foot intervals. (See figure 5-13.)

Lights for Work Areas

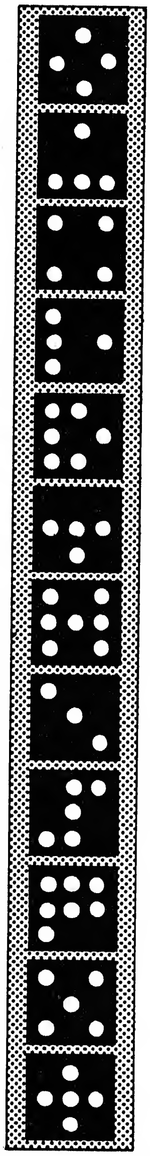
To minimize danger to personnel, red floodlights provide illumination in working areas on deck, in holds, and in cargo loading areas. A typical configuration is shown in figure 5-14.

VISUAL LANDING AIDS

Visual landing aids (VLA) are lighting devices and fixtures installed aboard nonaviation type

Table 5-1.—Station marking light box code

COMMODITY TRANSFERRED	STATION MARKER LIGHT BOX
MISSILES	
AMMUNITION	
FUEL OIL	
DIESEL OIL	
NAVY DISTILLATE (ND)	
AVGAS	
JET FUEL (JP-5)	
WATER	
STORES	
PERSONNEL AND/ OR LIGHT FREIGHT	
FUEL OIL AND JP-5	
ND AND JP-5	



27.368

ships to aid helicopter pilots in all-weather and night operations.

Primarily the VLA system consists of a Stabilized Glide Slope Indicator (SGSI). The SGSI projects a tri-colored beam of light (fig. 5-15) centered along a safe glide path to the ship. The upper sector of the light beam is green, the center portion (command path) is amber, and the lower section is red. In operation the helicopter pilot flies into (acquires) the beam and follows the command path to the ship. The glide slope indicator is mounted on a stabilized platform which compensates for the ship's roll and pitch to keep the projected glide path steady.

Other fixtures (fig. 5-16) indicate to the pilot the deck edge, the line-up position, the touchdown point, and any unfavorable landing condition. Various flood lights illuminate structures around the landing area for better depth perception.

NAVIGATION AND SIGNAL LIGHTS

Running, anchor, and signal lights include all external lights used for navigational and signaling purposes between ships to reduce the possibility of collision and to transmit intelligence. For design convenience, these lights are divided into three groups as follows:

(1) Navigation Lights (as specified by the International Rules of the Road):
- Masthead
- Minesweeping
- Range
- Side-port
- Side-starboard
- Stern (white)
- Towing
- Not-under-command (breakdown) and man-overboard
- Ship's task
- Anchor-aft
- Anchor-forward

(2) Signal Lights (Station or Operational):
- Aircraft warning
- Stern (blue)
- Wake
- Contour approach light (replenishment)
- Polarity signal
- Speed light (also used as aircraft warning or replenishment red truck lights)
- Station keeping (minesweeping)
- Identification light for submarines
- Station marking box (replenishment)
- Revolving beam ASW light

(3) Signal Lights (Visual Communication):
- Blinker
- 8-inch searchlight
- 12-inch searchlight (all types)
- Infrared transmitters
- Multipurpose signal light

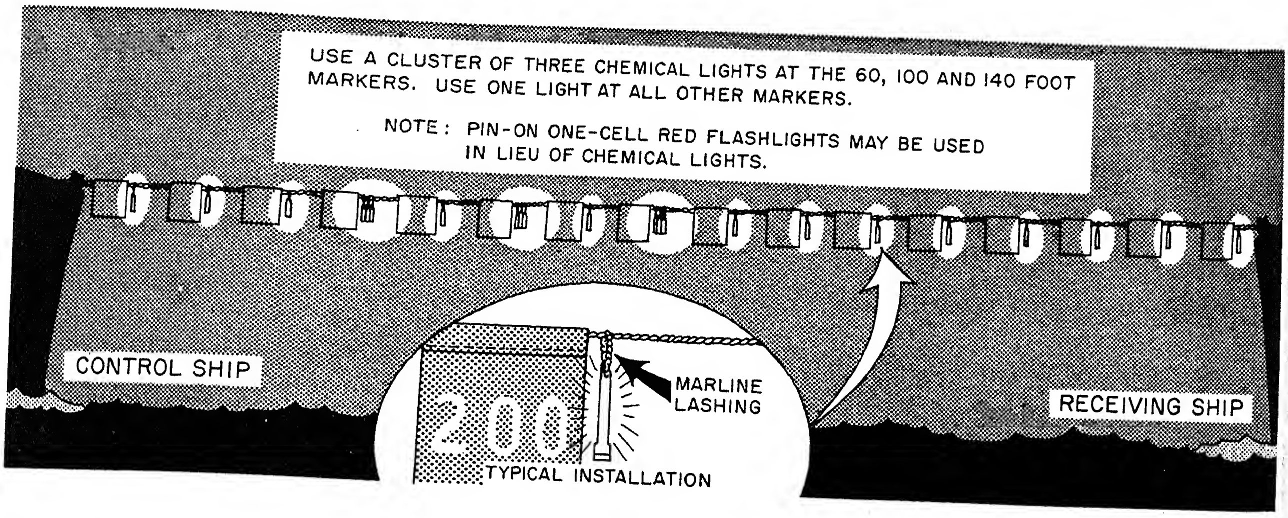


Figure 5-13.—Phone/distance line markings. 27.365

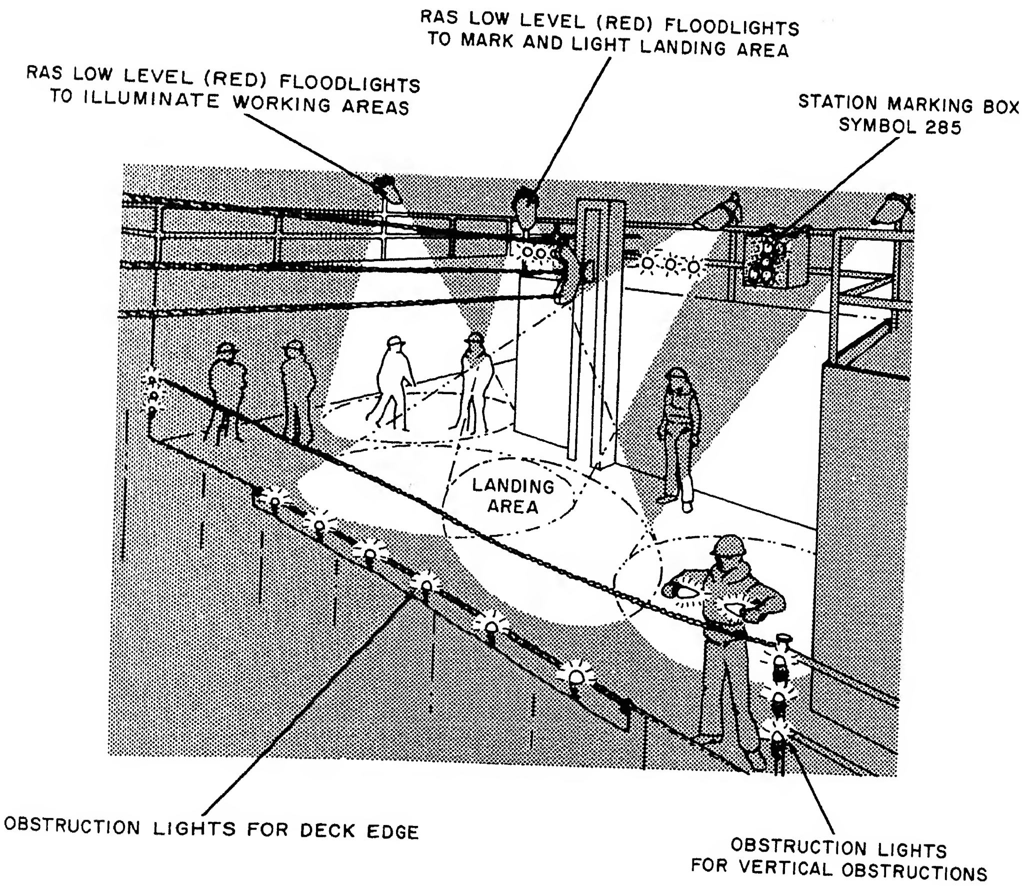
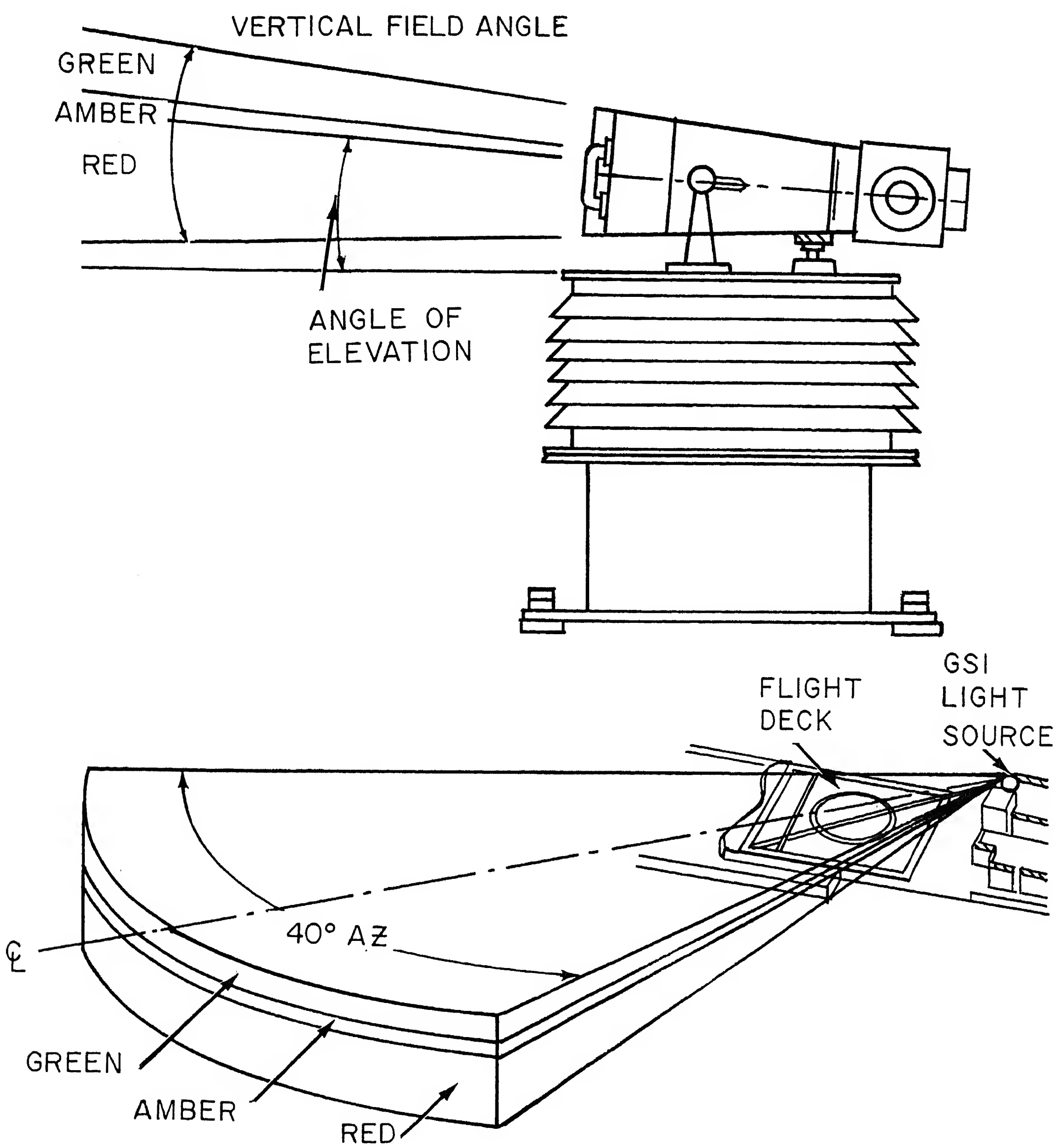


Figure 5-14.—RAS work area lighting on receiving ships. 27.366



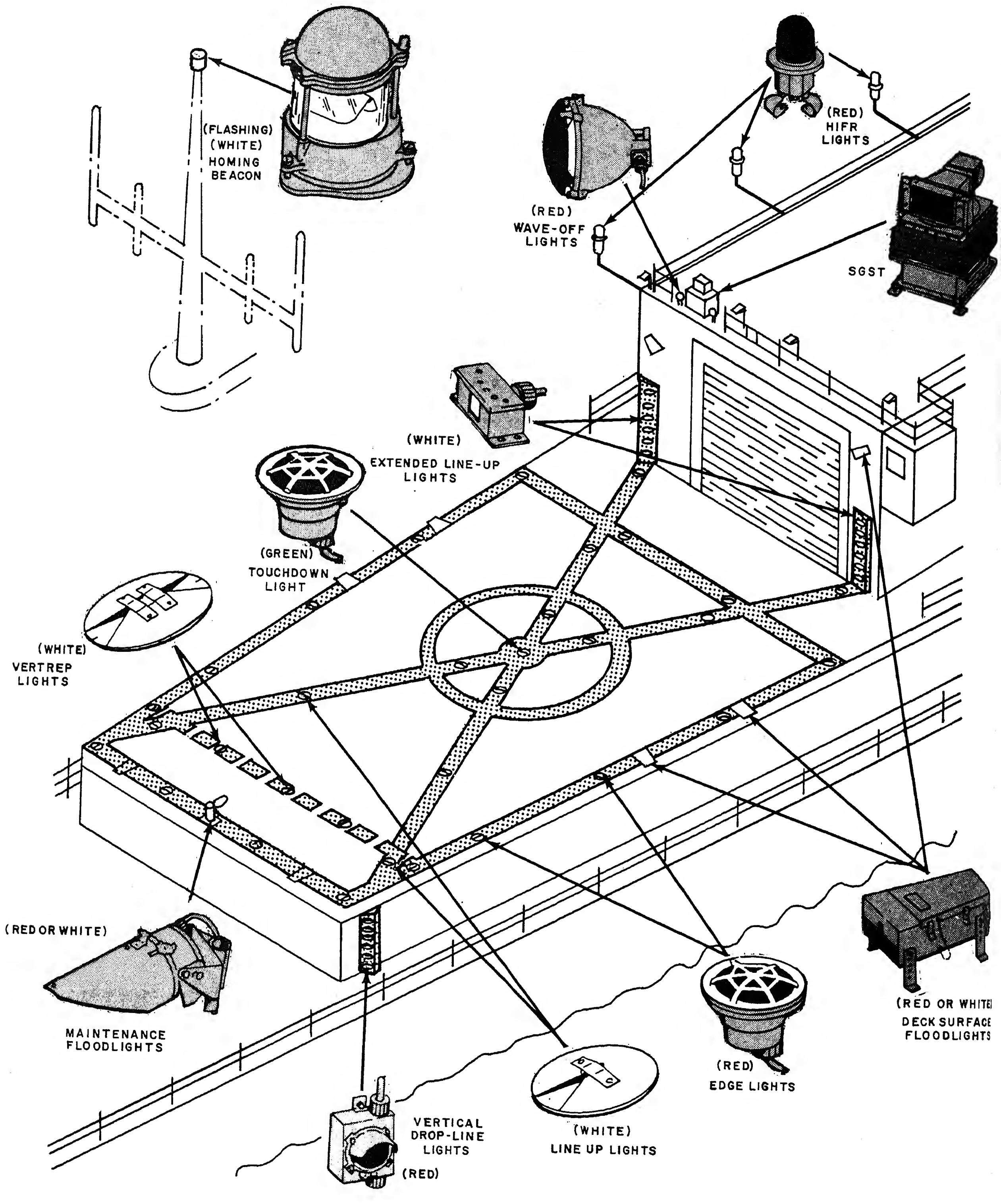
111.172

Figure 5-15.—Glide slope indicator and light beam.

Navigation Lights

The number location, arc, and range of visibility of the navigation lights, which must be displayed from sunset to sunrise by all ships in international waters, are established by the International Regulations for Preventing Collisions at Sea. Title 33, United States Code, Section 1051-1094, is the statutory law that requires the Navy to comply with the International Rules of the Road, or as allowed by an existing waiver to be issued covering the vessel being built.

MASTHEAD LIGHTS.—The masthead light (white) is a 20-point (225°) light located on the foremast or in the forward part of the vessel. It is a spraytight fixture provided with a 50-watt, 2-filament lamp and equipped with an



111.171

Figure 5-16—Typical VLA installation with flight deck and hangar on 0-1 level, dual landing approach.

external shield to show an unbroken light over an arc of the horizon of 20 points—that is, from dead ahead to 2 points abaft the beam on either side.

MINESWEEPING.—The minesweeping lights (green) are three 32-point (360°) lights arranged in a triangle on the forward mast. These lights are burned when mines are present to warn other ships of danger 3000 feet astern and 1500 feet on the sides.

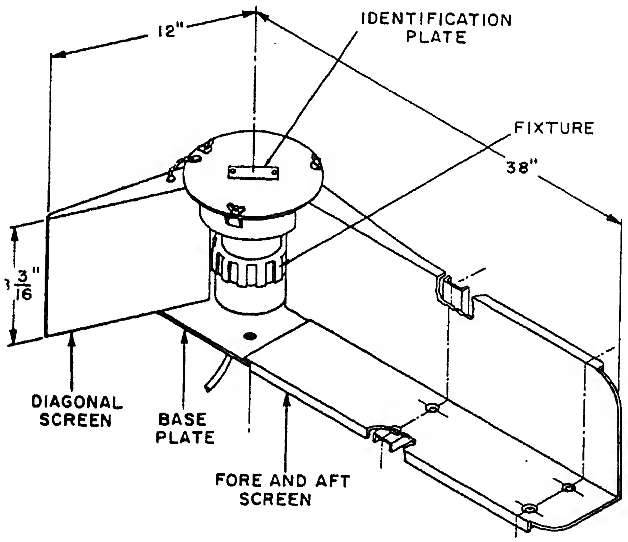
RANGE LIGHTS.—The range light (white) is a 20-point (225°) light located on the mainmast or the fore part of the vessel and is a spraytight fixture provided with a 50-watt, 2-filament lamp. The vertical distance of the range light must be at least 15 feet higher than the masthead light, and the horizontal distance must be greater than the vertical distance of the masthead light.

PORT AND STARBOARD SIDE LIGHTS.—The port and starboard side lights are 10-point (112 1/2°) lights (fig. 5-17) located on the respective sides of the vessel, showing red to port and green to starboard. The fixtures are spraytight, each provided with a 100-watt, 2-filament lamp and equipped with an external shield arranged to throw the light from dead ahead to 2 points abaft the beam on the respective sides.

STERN LIGHT.—The stern light (white) is a 12-point (135°) light located on the stern of the vessel. It is a watertight fixture provided with a 50-watt, 2-filament lamp and equipped with an external shield to show an unbroken light over an arc of the horizon of 12 points of the compass—that is, from dead astern to 6 points on each side of the ship.

TOWING LIGHTS.—The towing lights (white) for ships not normally engaged in towing operations are 20-point (225°) lights similar to the previously described masthead and range lights. They are portable fixtures, each equipped with a type THOF-3 cable and plug connector for energizing the lights from the nearest lighting receptacle connector. When these lights are used, they are located vertically (6 feet apart) in the fore part of the vessel. These lights can be permanently installed on ships whose normal operations call for towing, e.g., fleet tugs, salvage vessels, etc.

BREAKDOWN AND MAN-OVERBOARD LIGHTS.—The breakdown and man-overboard lights (red) are 32-point (360°) lights located 12 feet apart (vertically) and mounted on brackets



77.41

Figure 5-17.—Side light.

that extend aft of, and to starboard of the mast or structure. This arrangement permits visibility, as far as practicable, throughout 360° of azimuth. The fixtures are spraytight and equipped with 15-watt, 1-filament lamps. When these lights are used as a man-overboard signal, they are pulsed by a rotary snapswitch (fitted with a crank handle) on the signal and anchor light supply and control panel. These lights are mounted and operated in conjunction with the ship's task lights.

SHIP'S TASK LIGHT. — The ship's task light is an array consisting of three 32-point (360°) lights, stepped out 45° aft and to starboard of the mast, in a vertical line, one over the other, so that the upper and lower lights are the same distance from, and not less than 6 feet above or below, the middle light and are visible all around the horizon at a distance of at least 2 miles. The upper and lower lights of this array are red. The center light is clear white.

The ship's task lights are connected to the Navigational Light Supply and Control Panel so that:

(1) The two red lights will burn steadily to indicate that the ship is Not-Under-Command; or

(2) The two red lights will flash (by rotating the switch (crank type) handle) to indicate that a man-overboard condition exists; or

(3) The three lights will burn simultaneously to indicate that the ship is either launching or recovering aircraft or is engaged in replenishment-at-sea operations and, by the nature of her work, is unable to get out of the way of approaching vessels. The switch for this application is labeled "Ship's Task Lights."

FORWARD AND AFTER ANCHOR LIGHTS. — The forward and after anchor lights (white) are 32-point (360°) lights. The forward anchor light is located near the bow of the vessel, and the after anchor light is at the top of the flagstaff. The fixtures are splashproof, each provided with a 50-watt, 1-filament lamp. The anchor lights are energized through individual on-off rotary snap switches on the signal and anchor light supply and control panel in the pilothouse.

SUPPLY CONTROL AND TELLTALE PANEL. — The supply, control, and telltale panel for the running lights is a nonwatertight, sheet metal cabinet designed for bulkhead mounting (fig. 5-18).

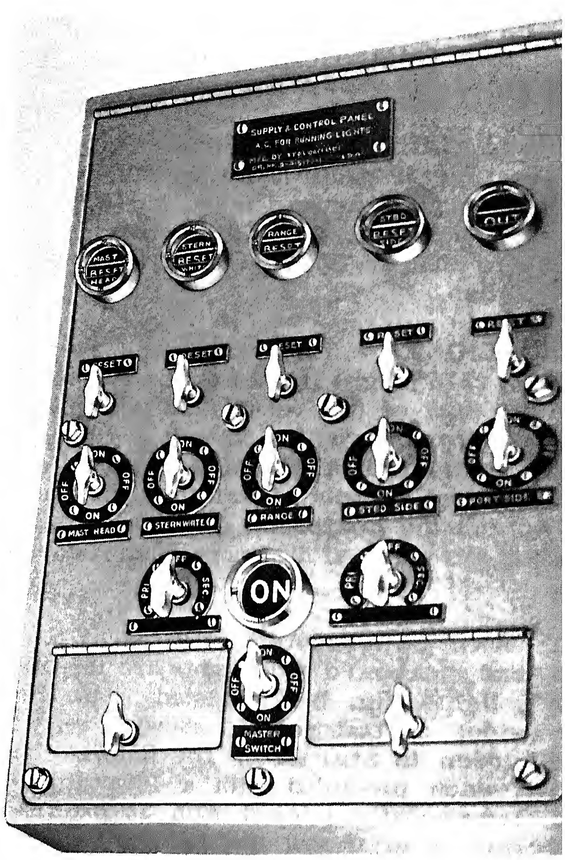


Figure 5-18.—Supply, control, and telltale

This panel is provided to aid a ship in k her running lights in operation as pres by the rules for preventing collisions : It is installed in or near the pilothouse an an alarm whenever one of the running (masthead, stern, range, and side lights) or has had a failure of its primary filam is operating on its secondary filament.

A dimmer control panel is used to d running lights when directed. This panel pr only one position for dimming. In the dim p the visibility of the range, masthead, side and stern light is reduced to approximatel yards.

Signal Lights (Station or Operational)

AIRCRAFT WARNING LIGHT. — The ai warning lights (red) are 32-point (360°)

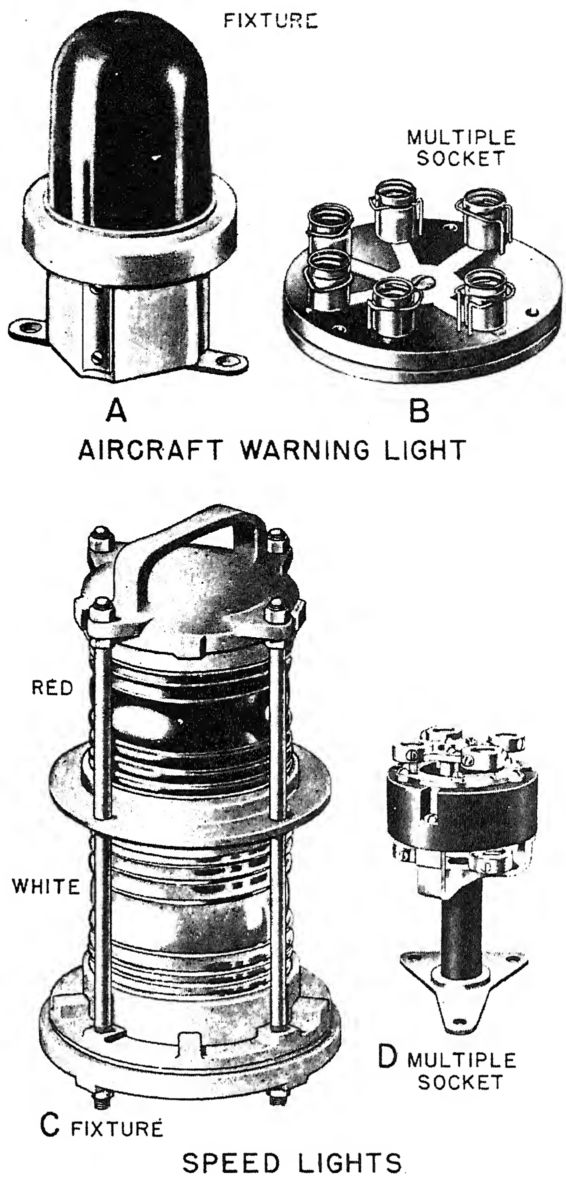
(fig. 5-19A) installed at the truck of each mast that extends more than 25 feet above the highest point in the superstructure. Two aircraft warning lights are installed if the light cannot be placed so that it is visible from any location throughout 360° of azimuth. However, a separate aircraft warning light is not required if a 32-point red light is installed at the truck of a mast for another purpose. The fixtures are spraytight and equipped with multiple sockets provided with 15-watt, 1-filament lamps (fig. 5-19A). If a single lamp fails, all of the lamps in the cluster should be replaced.

SPEED LIGHTS.—The speed lights are combination red (top) and white (bottom), 32-point (360°) lights (fig. 5-19B). They are located at the truck (top) of the mainmast, except when the height of the foremast is such that it interferes with their visibility; in this case, they are located at the truck of the foremast. Two speed lights are installed if their light cannot be placed so that they are visible throughout 360° of azimuth.

Speed lights are provided to indicate (by means of a coded signal) the speed of the vessel to ships in formation. In other words, they indicate the order being transmitted over the engine order system. The white light indicates ahead speeds, and the red light indicates stopping and backing. The fixture is spraytight and equipped with a multiple socket (fig. 5-19B) provided with nine 15-watt, 1-filament lamps. Six lamps are used in the top of the socket for the red light and three in the bottom for the white light; each light is energized from a separate circuit.

The controller for the speed lights is located in the pilothouse and is energized through the supply switch on the signal and anchor light control and supply panel. The speed light system operates automatically when the circuit control switch is placed in the MOTOR PULSE position and the signal (speed) selector switch is set in the desired position. This action established connections to the motor-driven pulsator to provide the signals.

STERN LIGHT.—The stern light (blue) is a 12-point (135°) light similar to the previously described white stern light. The light is installed near the stern on ships that are engaged in convoy operations and is mounted to show an unbroken arc of light from dead astern to six points on each side of the ship.



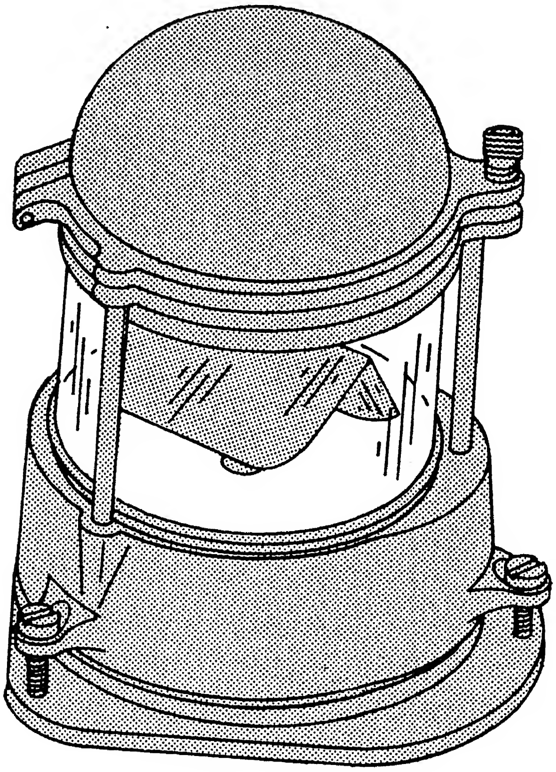
77.44
Figure 5-19.—Aircraft warning and speed lights.

WAKE LIGHT.—The wake light (white) is installed on the flagstaff or after part of the ship to illuminate the wake and is mounted so that no part of the ship is illuminated. The fixture is spraytight and of tubular construction. One end of the fixture is fitted with an internal screen, having a 1-inch diameter hole provided

with a lens through which light is emitted from a 100-watt, 2-filament lamp. A suitable mounting bracket is included for adjusting the position of the light. Thus, the wake light puts a "target" in the ship's wake.

SUBMARINE IDENTIFICATION LIGHT.—The submarine identification light is displayed solely for identifying a craft on the surface as a submarine. Its display does not change any of the Rules of the Road nor confer any privilege on the ship showing it. The light is an amber rotating light producing 90 flashes per minute, visible all around the horizon, and located approximately 6 feet above the masthead light.

REVOLVING BEAM ASW LIGHT.—The revolving beam ASW light (fig. 5-20) is displayed for intership signaling during ASW operations and is installed on all ships equipped to participate in ASW operations. The light is positioned on either the yardarm or mast platform where it



27.367
Figure 5-20.—ASW revolving beacon.

can best be seen all around the horizon. Two red, two green, and two amber lenses are provided with each fixture. Colors to be used are determined by operating forces.

Signal Lights (Visual Communication)

The signal lights for visual communication include the blinker lights located on the yardarm and the 8- and 12-inch searchlights.

BLINKER LIGHTS.—The blinker lights (white) are used in much the same manner as searchlights for communication but, because of their location, many ships can receive the message at the same time. They are located, one port and one starboard, outboard on the signal yardarm. The fixtures are spraytight, each provided with two clusters of six 15-watt, 1 filament lamps. Cluster #1 may be used singly for normal use. Through switching, cluster #2 may be added to #1 to increase brilliance for communication at greater distance, or #2 may be selected alone if #1 fails. The lights are operated from signal keys located on each side of the signal bridge.

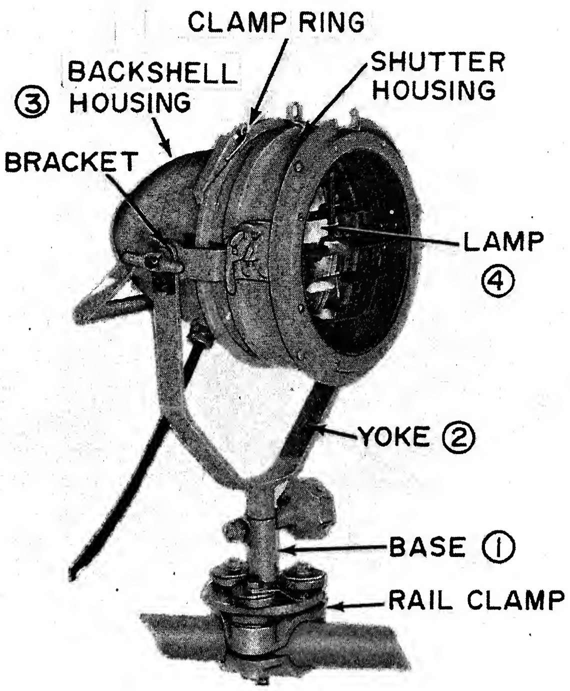
SEARCHLIGHTS.—Naval searchlights are used to project a narrow beam of light to illuminate distant objects. They are also used for visual signaling. To accomplish its purposes, the searchlight must have an intense, concentrated source of light, a reflector that collects light from the source (to direct it in a narrow beam), and a signal shutter (to interrupt the beam of light).

Searchlights are classified according to the size of the reflector and the light source. The 8-inch searchlight has an incandescent light source, and the 12-inch can have either an incandescent or an inert gas light source.

The 8-inch signaling searchlight utilizes an incandescent sealed beam lamp. It is designed to withstand high vibratory shock and extreme humidity conditions and will operate equally well in hot or cold climates.

This searchlight may be furnished for operation with either a 60-hertz, 115-volt transformer to step the voltage down to 23 volts, or without a transformer to operate on 115 volts using the proper rated sealed beam unit. The same unit is available for use on small craft from a 28-volt power source.

The searchlight (fig. 5-21) consists of the (1) base, (2) yoke, (3) housing, and (4) lamp. The base is equipped with a rail clamp to secure the searchlight to the rail. The yoke is swivel-mounted on the base so that it can be trained through 360°. The housing provides an enclosure



77.62
Figure 5-21.—8-inch 60-hertz sealed-beam searchlight.

for the lamp and is composed of a front and a rear section. The front section comprises the shutter housing, and the rear section comprises the backshell housing. The two sections are held together by a quick-release clamp ring that permits easy replacement of the lamp. The backshell and lamp assembly, when detached, may be used as a portable searchlight. The entire housing is mounted on brackets attached to the shutter housing and is supported by the yoke to allow the searchlight to be elevated or depressed. Clamps are provided to secure the searchlight in train and elevation.

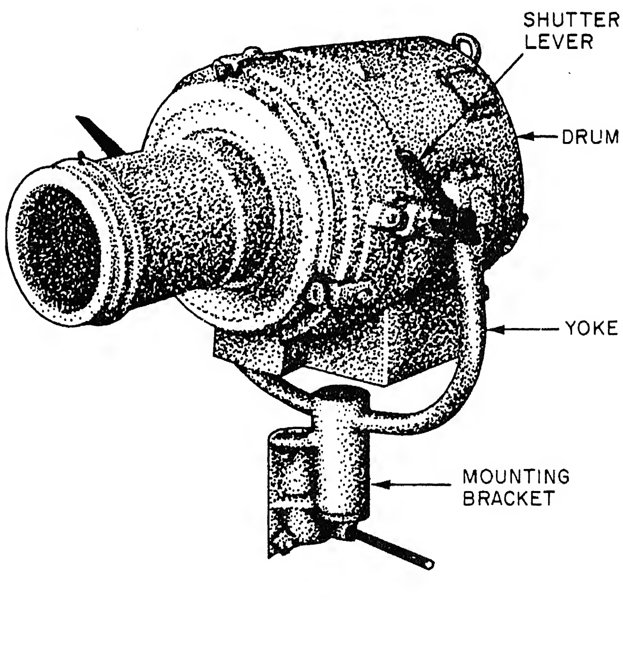
The shutter housing (fig. 5-21) contains the venetian blind shutter, which is held closed by springs and is manually opened by a lever on either side of the housing. The front of the shutter housing is sealed by the cover glass and a gasket. The rear of the shutter housing is enclosed by a gasket and adapter assembly. The adapter assembly provides a locating seat for the lamp and incorporates a hook and key arrangement that aligns the backshell housing and retains it in position while attaching the clamp ring to hold the two sections together.

Three filter assemblies (red, green, and yellow) are provided and can be readily snapped in place over the face of the searchlight. The shutter vanes can be locked in the open position for use as a spotlight.

The backshell housing provides an enclosure for the 115/23-volt transformer.

The 12-inch incandescent searchlight is used primarily for signaling and secondarily for illumination. The searchlight (fig. 5-22) is comprised of (1) mounting bracket, (2) yoke, (3) drum, and (4) lamp (not shown). The mounting bracket permits the searchlight to be secured to a vertical pipe or to a flat vertical surface. The yoke is swivel-mounted on the bracket to allow the searchlight to be rotated continuously in train. The steel drum provides housing for the lamp and is trunnion-mounted on the yoke to allow it to be elevated and depressed. Clamps are provided for locking the searchlight in any position of train and elevation.

The SIGNALING SHUTTER is a venetian-blind shutter mounted inside the drum behind the front door. It is held in the closed position by two springs and is manually opened by a lever on either side of the drum. The parabolic metal reflector is mounted on the inside of the rear door.



77.58
Figure 5-22.—12-inch incandescent searchlight.

The LAMP is usually a 1000-watt, 117-volt incandescent lamp having special concentrated filaments that reduce the area of the light beam. The lamp is mounted in a mogul bipost socket. The socket is located in front of the reflector and can be adjusted only slightly. The lamp can be replaced through the rear door of the searchlight.

The light source must be at the focus of the reflector for minimum beam spread and maximum intensity. Some types of 12-inch incandescent searchlights are provided with focusing adjustment screws. Other types can be adjusted by loosening the screws that hold the lamp-socket support plate in position. Move the entire socket assembly toward or away from the reflector until the beam has a minimum diameter at a distance of 100 feet or more from the light, and retighten the screws. When checking the diameter of the beam, be sure the rear door is tightly clamped shut.

A screen hood is provided for attachment to the front door to limit the candle power of the beam, to cut down its range, and to reduce stray light, which causes secondary illumination around the main beam. The hood also provides for the use of colored filters.

The 12-inch mercury-xenon arc lamp (fig. 5-23) has a 1000-watt short-arc and requires 45 amperes to start and 18 amperes to operate. It is supplied from the ship's 117-volt, 60-hertz, single-phase power. The lamp consists of two tungsten electrodes spaced approximately 1/4 inch apart inside a 2-inch diameter quartz bulb. The bulb contains a small quantity of liquid mercury and xenon gas at a pressure of 3 to 5 atmospheres when the lamp is cold (an atmosphere at sea level is equivalent to 14.7 psi). After the arc is started and the lamp attains a stable operating temperature, the internal pressure increases to approximately 20 atmospheres. The lamp does not produce full-light output until this pressure is reached and all of the mercury has been vaporized. The lamp differs from the incandescent lamp in that it requires a high voltage, RF current for starting and a ballast for operating at rated output. Because of the high voltages involved and the high pressure of these lamps, safety precaution should be observed.

The LAMP ADJUSTER ASSEMBLY is secured to the top of the searchlight drum and extends inside the drum to provide a mounting for the mercury-arc lamp. The assembly affords longitudinal traverse (toward or away from the reflector), horizontal (from side to side), and vertical adjustments of the lamp.

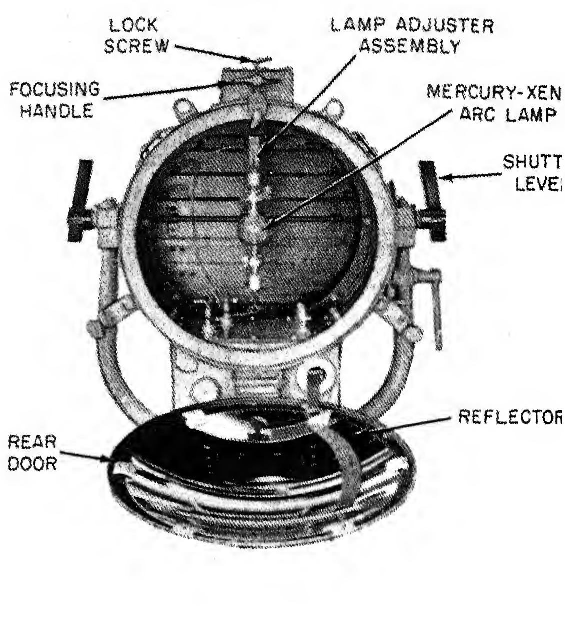


Figure 5-23.—12-inch mercury-xenon searchli

The BALLAST UNIT, located out of weather near the searchlight, consists of transformer and five resistors enclosed i steel box. The unit provides the necess ballast voltage in series with the lamp to ma tain constant current for normal operation.

The STARTER UNIT, enclosed in a wat tight box, is mounted in the lamp housing consists of the necessary components for start and operating the lamp. The electrical connecti from the ballast unit to the starter unit provided by a cable equipped with a waterti plug.

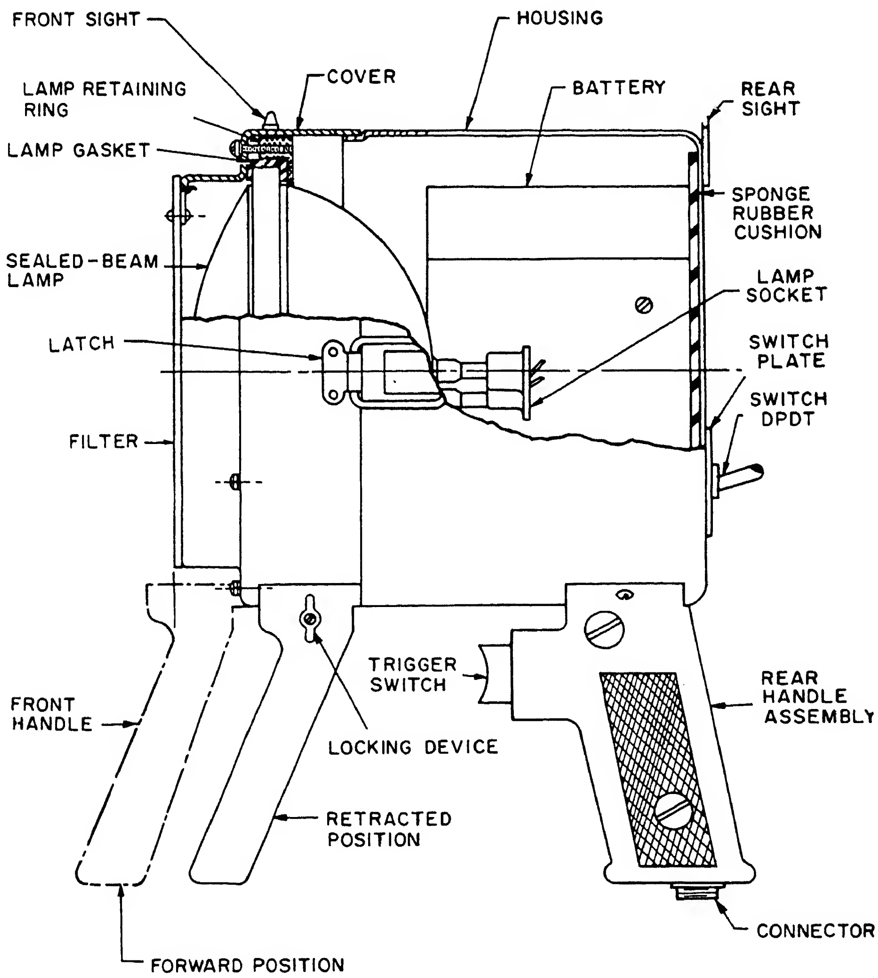
When the lamp is extinguished, whether or cold, the internal resistance between electro is so high that the arc will not restart w normal line voltage is applied. Hence, a spe high-voltage, RF circuit is incorporated to prov instant starting, irrespective of whether the la is cold or hot. However, the lamp is har to start while it is hot and at maximum inte pressure. The RF circuit is capable of produc a voltage from 40,000 to 60,000 volts. After arc is started, the lamp will operate on nor voltage of 60 to 70 volts.

The ship's single-phase, 115-volt, 60-he power is supplied to the ballast unit throug disconnect switch located adjacent to the sear light.

INFRARED TRANSMITTERS.—The infrared transmitters (beacons) are designed to operate in the infrared frequency spectrum. Because infrared radiation is invisible, these transmitters provide a means for signaling at night during darkened-ship conditions. The beacons are located on either side of the signal yardarm and may be operated separately or simultaneously by either of two manual keys. An infrared receiver is used by the receiving ship to observe the signal from the transmitting ship.

MULTIPURPOSE SIGNAL LIGHT.—The portable multipurpose signal light (fig. 5-24) produces a high intensity beam of light suitable for use as a spotlight or as a blinker (by means of a trigger switch located on the rear handle) for visual communications. The light is designed to operate from an internal battery (three type BA-2 dry cells connected in parallel), or from the 120-volt a.c. ship's supply via a 120/20-volt transformer mounted in the stowage box. The front handle is adjustable to assure a steady position for signaling, and front and rear sights provide for holding the beam on the desired target.

Supplied with the light, in addition to the stowage box, are red, green, and yellow lenses, a 15-foot power cable for supplying power from the ship's a.c. source to the stowage box, a 25-foot cable for supplying power from the



101.5

Figure 5-24.—Multipurpose signal light.

stowage box to the light, and the manufacturer's technical manual.

Floodlights and Lanterns

FLOODLIGHTS.—The floodlight (fig. 5-25A) consists of a splashproof housing equipped with a rain-shielded, hinged door secured with a trunk type latch. The 300-watt lamp is the sealed-beam type. The lamp housing is trunnioned on a yoke which in turn is mounted on a sho absorbing base. The light is secured in elevati by a clamp on the yoke. Train positioning accomplished by friction within the shock a sorbing base. Each floodlight is furnished wit 3-conductor cable (including a green lead to grou the metal housing) for connection into the lighti circuit.

Larger 500-watt floodlights (not shown), usi a mogul screw base lamp, are also widely use

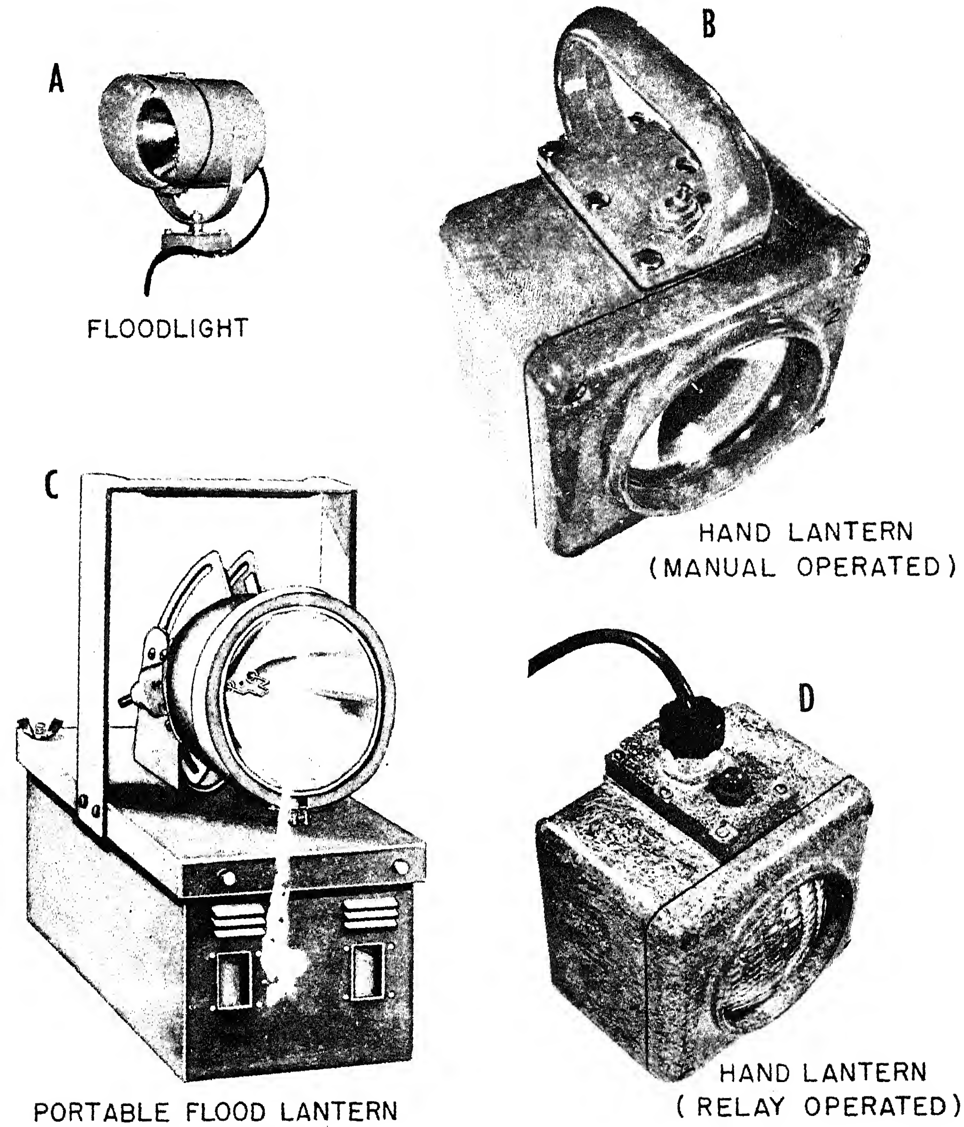


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Figure 5-25.—Floodlights and lanterns.

Floodlights are installed on weather decks at suitable locations to provide sufficient illumination for the operation of cranes and hoists, and the handling of boats. New high-level illuminating floodlights are being developed for evaluation by Naval Sea Systems Command.

Two types of dry battery lanterns are available for installation in certain strategic locations to prevent total darkness in case the lighting power fails. One model is hand operated. The other is operated automatically by a relay when the regular power fails.

MANUALLY OPERATED HAND LANTERN.—The manually operated hand lantern (fig. 5-25B), consists of a watertight plastic case containing two (6-volt) batteries connected in parallel. It includes a sealed beam lamp, rated at 5 volts, but operated at 6 volts (when the batteries are new) to increase the light output. A rigid handle is secured to the top of the case. The lantern is operated by a toggle switch, the lever of which is convenient to the thumb. When the batteries are fresh, the lantern can be used continuously for approximately 8 hours before the light output ceases to be useful.

Manually operated lanterns are installed as an emergency source of illumination in spaces that are manned only occasionally. These lanterns are also used in certain areas to supplement the relay-operated lanterns.

Manually operated hand lanterns must not be removed from the compartments in which they are installed unless the compartments are to be abandoned permanently.

RELAY-OPERATED HAND LANTERN.—The relay-operated hand lantern is similar to the manually operated type except that the relay housing is mounted topside of the lantern case (fig. 5-25D) in place of the handle. The 115-volt a.c. version is identified by symbol 101.2. Symbol 102.2 identifies the 115-volt d.c. type. A 3-conductor cable (including a green conductor to ground the relay metal frame) is provided for connection into the lighting circuit. THE RELAY-CONTROLLED LANTERN MUST ALWAYS BE INSTALLED WITH THE RELAY UPPERMOST. This specific arrangement of the relay prevents a proven fire hazard, which would be caused if the liquid electrolyte (formed from battery exhaustion) drained into the (otherwise inverted) relay housing.

Relay-controlled lanterns are assigned to spaces which require practically continuous illumination. These spaces include essential watch stations, control rooms, machinery spaces, and battle dressing stations. The lanterns must illuminate the tops and bottoms of all ladders and flush-mounted scuttles. They must also be mounted so as to illuminate all gages at vital watch stations. Operating personnel will depend on these lanterns for illumination when bringing the machinery back on the line in the event of a casualty. These lanterns must not be installed in magazine or powder-handling spaces in which fixed or semifixed ammunition is handled, or in any location in which explosion-proof equipment is required.

The lantern relay is connected in the lighting circuit (in the space in which the lantern is installed) on the power supply side of the local light switch that controls the lighting in the space concerned. Thus, the relay is operated and will restore, causing the lamp in the lantern to be energized from its batteries only when power failure occurs, but not when the lighting circuit is deenergized by the light switch. If the space is supplied with both emergency and ship's service lights, the lantern relay is connected to the emergency lighting circuit only.

PORTABLE FLOOD LANTERN.—The portable flood lantern (fig. 5-25C) consists of a sealed beam lamp enclosed in a built-in lamp housing equipped with a toggle switch. The lamp housing is adjustably mounted on a drip-proof, acid-resistant case provided with two windows in each end.

The case contains four Navy type BB-254/U storage cells. Each cell contains a channeled section in which a green, a white, or a red ball denotes the state of charge of the cell through a viewing window. When a cell is fully charged, all three indicator balls float at the surface of the electrolyte. The green ball sinks when approximately 10% of the cell capacity has been discharged; the white ball sinks when the cell is 50% discharged; and the red ball sinks when the cell is 90% discharged.

The lamp is rated at 6 volts but is operated at 8 volts to increase the light output. When operated with fully charged batteries, the lantern can be operated continuously for approximately 3 hours without being recharged. The batteries should be recharged as soon as possible after the green ball (10 percent discharged) has sunk to the bottom. The lanterns should be checked at least once a week to determine whether the green indicator balls are floating. If they are not floating, the battery should be charged at a rate of 1 1/2 to 2 amperes until all indicator balls

are floating at the indicator line. If the battery is completely discharged, it will require from 20 to 25 hours to recharge it. After the charging voltage has remained constant at 10 volts for 1 hour, discontinue the charging.

When necessary, add pure distilled water to keep the electrolyte level at the indicator line marked on the front of the cell. Do not add enough water to bring electrolyte level above the line because overfilling nullifies the nonspill feature of the battery and may cause the electrolyte to spurt out through the vent tube. However, if the electrolyte level is not at the indicator line, the charge indicator balls will not indicate correctly the state of charge of the battery.

Portable flood lanterns are often referred to as damage control lanterns because they are used by damage control personnel to furnish high intensity illumination for emergency repair work or to illuminate inaccessible locations below deck.

MAINTENANCE

The intensity of illumination produced by lighting installation begins to depreciate at th time the system is placed into operation. Th greatest loss of light (up to 30%) can usuall be attributed to dirt and oil on lamps an fixtures. A regular program of fixture and lam cleaning will improve illumination aboard yo ship.

Burned out incandescent lamps may be dis posed of at sea, but for security reasons, must be remembered that incandescent lamps wi float and therefore must first be broken.

Fluorescent lamps contain mercury gas whi is poisonous. Therefore, all fluorescent lamp must be collected and turned into a shore-bas control point for land disposal. NO FLUOR ESCENT LAMPS SHALL BE DUMPED INT ANY BODY OF WATER, INCLUDING OCEAN

CHAPTER 6

DEGAUSSING

A steel-hulled ship is like a huge floating magnet. Because of its magnetic field, the ship can act as a triggering device for magnetically sensitive mines. Degaussing concerns the methods and techniques of reducing the effects of the ship's magnetic field to minimize the possibility of detection by magnetic mines and other magnetic influence detection devices.

The earth's magnetic field has various strengths throughout the earth's surface. The sensor of a magnetic mine is set to the strength of the earth's magnetic field at the mine's location. Now, if any ferrous metal is introduced into the earth's magnetic field near the mine, the magnetic field around the sensor will be distorted, causing the mine to blow up.

A steel ship which has received no antimagnetic, or degaussing, treatment has a large magnetic field surrounding its hull. As the ship moves through the water, this field also moves and adds to, or subtracts from, the earth's magnetic field causing it to bend or move. To a magnetic mine beneath the ship, this moving magnetic field (ship) appears as a change or variation in the surrounding magnetic environment. Magnetic ordnance is highly sensitive to variations in the earth's magnetic field. When the ship is degaussed, its field is altered or modified so the ordnance can detect little, if any, magnetic disturbance as the ship passes.

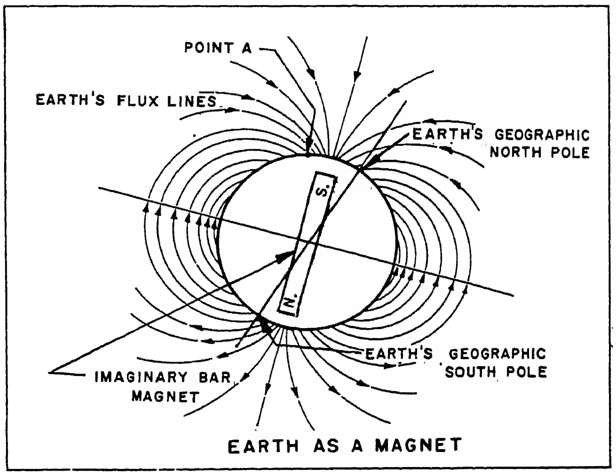

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Figure 6-1.—Earth's magnetic field.

EARTH'S MAGNETIC FIELD

The earth's magnetic field acts upon all metal objects on or near the earth's surface. Figure 6-1 shows the earth as a huge permanent magnet, 6000 miles long, extended from the arctic to the antarctic polar regions. Lines of force from this magnet extend all over the earth's surface, exerting a magnetic influence on all ferrous materials that are on or near the surface. Since many of these ferrous materials themselves become magnetized, they distort the background field into irregular eddies and areas of greatly increased or decreased magnetic strength. Thus, the lines of magnetic force at the earth's surface do not run on straight, converging lines like the meridians on a globe, but appear more like the isobar lines on a weather map.

By convention, the external direction of the magnetic field of a bar magnet is from the north pole to the south pole. Lines of force for the earth's field, however, leave the earth in the southern hemisphere and reenter in the northern hemisphere. Therefore, we must think of the polar region in the arctic as the north-geographic, south-magnetic pole, which describes the direction of polarity used in the field of degaussing.

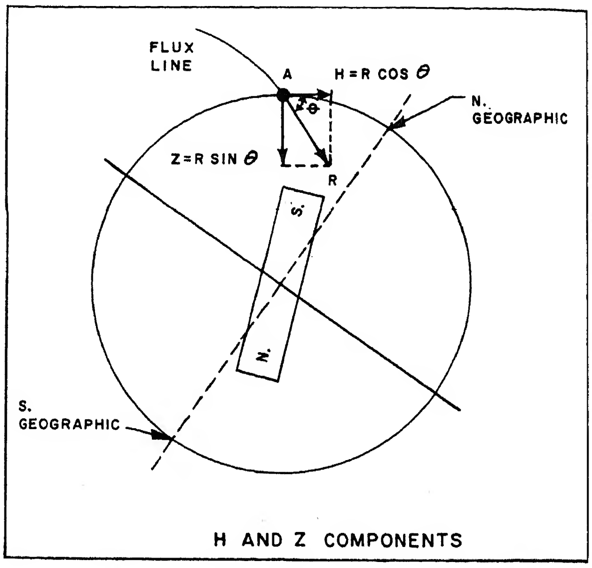
Note in figure 6-1 that the magnetic meridians form closed loops, arching from the earth's

magnetic core to outer space and reentering the earth in the opposite hemisphere. Since all lines of magnetic force return to their points of origin, they form closed magnetic circuits. An idea of the size of the earth's magnetic field is apparent when you notice that lines of force at the polar regions seem to extend vertically into space. The size of the closed loops formed by these lines of force is staggering to the imagination. It is impossible to eliminate the earth's field; however, the effects of the ship on this field may be lessened. Degaussing limits the ship's distortion of the earth's magnetic field, and some highly developed techniques are used in the process.

The strength and direction of the earth's field at any point is a function of the strength of the individual components. The angle of the field with the horizontal, sometimes called the dip, may be easily determined by a dip needle, a simple compass needle held with the needle pivot axis parallel to the earth's surface. Since a compass needle always aligns itself parallel to the lines of force of a magnetic field, the dip needle indicates the angle of the earth's field to the horizontal by aligning itself with the lines of force entering or leaving the earth at that point. Both direction and strength of the field may be determined by means of a mine search coil and flux-measuring equipment.

Since the earth's field can be resolved into two components, the horizontal (H) component and the vertical (Z) component, the vector sum of the H and Z components will define the magnitude and the direction of the total field at any point on the earth's surface. The force of the magnetic flux can be resolved into a horizontal and a vertical component as shown in figure 6-2.

Table 6-1 shows horizontal and vertical component strength, and the resulting total field strength and direction for several representative geographical locations in the northern and the southern hemispheres. Note that the vertical component may be assigned either a positive or negative value because lines of force leave the earth in the southern hemisphere and reenter in the northern hemisphere. Therefore, the upward field in the southern hemisphere is assigned a negative value, and the downward field in the northern hemisphere is assigned a positive value. There are two areas of maximum vertical intensity but opposite polarity—the north and south magnetic poles. The vertical intensity at the magnetic equator is zero since the entire field is horizontal.



27.104

Figure 6-2.—Horizontal and vertical components of earth's magnetic field.

SHIP'S MAGNETIC FIELD

The magnetic field of a ship is the resultant of the algebraic sum of the ship's permanent magnetization and the ship's induced magnetization. The ship's magnetic field may have any angle, with respect to the horizontal axis of the ship, and any magnitude.

SHIP'S PERMANENT MAGNETIZATION

The process of building a ship in the presence of the earth's magnetic field develops a certain amount of permanent magnetism in the ship. The magnitude of the permanent magnetization depends on the earth's magnetic field at the place where the ship is built, the material of which the ship is constructed, and the orientation of the ship at time of building with respect to the earth's field.

Table 6-1.—Measurements of the earth's magnetic field at selected locations

LOCATION	HORIZONTAL (H) COMPONENT	VERTICAL (Z) COMPONENT	TOTAL FIELD STRENGTH	DIRECTION OF TOTAL FIELD
North Pole (Magnetic)	0	+620	620	90° down
Fairbanks, Alaska	120	+560	570	78° down
Stockholm, Sweden	150	+460	490	70° down
London, England	190	+440	470	69° down
Washington, D.C.	180	+540	570	72° down
Tokyo, Japan	300	+340	460	50° down
Manila, Philippine Islands	390	+100	410	14° down
Equator (Magnetic)	410	0	410	0° horizontal
Rio de Janeiro, Brazil	230	-080	250	20° up
Capetown, South Africa	140	-280	320	64° up
Buenos Aires, Argentina	230	-140	260	30° up
Melbourne, Australia	230	-560	610	68° up
South Pole (Magnetic)	0	-720	720	90° up

NOTE—All measurements are approximate.

27.378

The ship's permanent magnetization can be resolved into the (1) vertical permanent field component and (2) the horizontal permanent field component. The horizontal permanent field component can be resolved into the longitudinal permanent field component and the athwartship permanent field component. The vertical, longitudinal, and athwartship permanent field components of the ship are virtually constant and are not affected by changes in heading or magnetic latitude.

All ships that are fitted with shipboard degaussing installations, and other ships that do not require degaussing installations, are depermed. Deperming is essentially a large-scale version of demagnetizing a watch. The purpose is to reduce permanent magnetization and bring all ships of the same class into a standard condition so that the permanent magnetization, which remains after deperming, is approximately the same for all ships of that class.

SHIP'S INDUCED MAGNETIZATION

Any piece of iron in a magnetic field will have magnetism induced in it. Therefore a ship, by its very existence in the earth's magnetic field, has a certain amount of magnetism induced in it. The ship's induced magnetization depends on the strength of the earth's magnetic field and on the heading of the ship with respect to the earth's field.

The ship's induced magnetization, like the ship's permanent magnetization, can be resolved into the (1) vertical induced field component and (2) the horizontal induced field component. The horizontal induced field component is also comprised of the longitudinal induced field component and the athwartship induced field component.

Table 6-1 shows the force of the earth's field which causes magnetic induction on the ship. Therefore, the magnitude of vertical induced

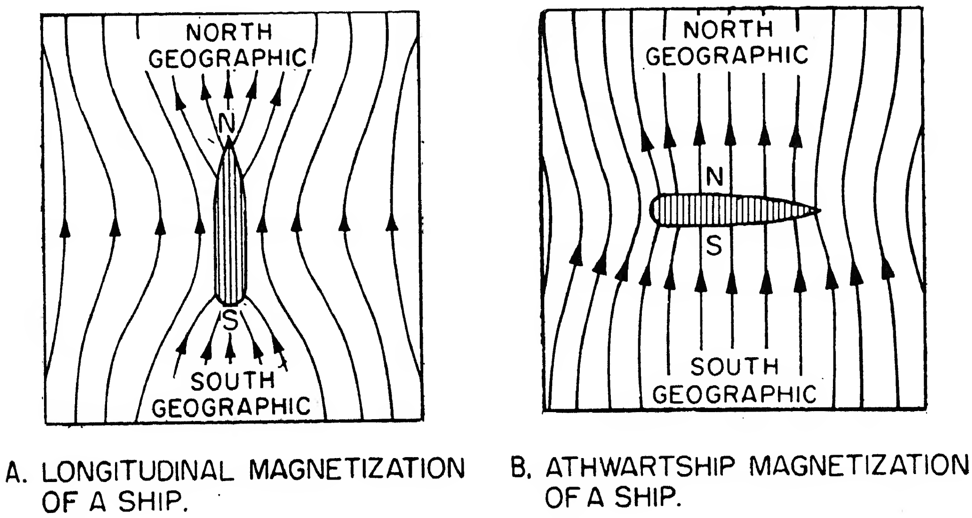
magnetization depends on the magnetic latitude. Remember the vertical induced magnetization is maximum at the magnetic poles and zero at the magnetic equator.

The vertical induced magnetization is directed downward whenever the ship is north of the magnetic equator and upward whenever the ship is south of the magnetic equator. Hence, the vertical induced magnetization changes with magnetic latitude, and to some extent, when the ship rolls or pitches. The vertical induced magnetization does not change with heading because a change of heading does not change the orientation of the ship with respect to the vertical component of the earth's magnetic field.

The longitudinal induced magnetization changes when either the magnetic latitude or the heading changes and when the ship pitches. If a ship is headed in a north-geographic direction, the horizontal component of the earth's magnetic field induces a north pole in the bow and a south pole in the stern (fig. 6-3A). In other words, the horizontal component of the earth's field induces a longitudinal, or fore-and-aft, component of magnetization. The stronger the horizontal component of the earth's magnetic field, the greater will be the longitudinal component of magnetization. If the ship starts at the south magnetic pole and steams toward the north magnetic pole, the longitudinal component of induced magnetization starts at zero at the south magnetic pole, increases to a maximum at the magnetic equator, and decreases to zero at the north magnetic pole. Hence, for a constant heading the longitudinal component of induced magnetization changes when the ship moves to a position where the horizontal component of the earth's magnetic field is different—that is, when the ship changes its magnetic latitude.

If at a given magnetic latitude the ship changes headings from north to east, the longitudinal component of induced magnetization will change from a maximum on the north heading to zero on the east heading. When the ship changes heading from east to south, the longitudinal component increases from zero on the east heading to a maximum on the south heading. On southerly headings a north pole is induced at the stern and a south pole at the bow, which is the reverse of the conditions on northerly headings. The longitudinal component of induced magnetization also changes, to some extent as the ship pitches.

The athwartship induced magnetization changes whenever either the magnetic latitude or the heading changes, and whenever the ship rolls or pitches. When a ship is on an east heading a north pole is induced on the port side and a south pole on the starboard side (fig. 6-3B) which is the athwartship component of induced magnetization. The magnitude of the athwartship magnetization depends on the strength of the horizontal component of the earth's magnetic field at that latitude. This component is maximum



27.105:

Figure 6-3.—Effect of the earth's magnetic field upon a ship.

at the magnetic equator for a ship on an east-west heading and zero at the magnetic poles for a ship on a north-south heading.

MAGNETIC RANGES AND RANGING

A magnetic range is a station equipped to measure the magnetic field of ships which pass over measuring equipment located at or near the bottom of the channel in which the ships travel. The magnetic range is more commonly called a Degaussing Range or Degaussing Station.

A ship is said to be "ranged" when its magnetic field is measured at a magnetic range. Ranging has two classifications: calibration ranging and check ranging.

CALIBRATION RANGING

Calibration ranging provides information for degaussing charts, determines initial degaussing coil current, and indicates whether changes or modification to the ship's degaussing installation are required.

CHECK RANGING

Check ranging determines the adequacy of current settings and the performance of degaussing equipment as well as personnel.

For accurate ranging the ship must pass directly over the range at a constant speed and heading. The degaussing coils must be set correctly in accordance with the values given in the degaussing folder. For depth correction, the range officer must be notified of coil settings and of the ship's draft, forward and aft, to the nearest 6 inches.

DEGAUSSING FOLDER

The ship's Degaussing Folder is a record of the degaussing installation in the ship. The folder contains (1) a description of the degaussing installation, (2) a record of inspections, tests, and repairs performed by repair activities, (3) the values of all coil currents for the ship's positions and headings, and (4) a record of the degaussing range runs. The Degaussing Folder is necessary to the operation of the degaussing system and must be safeguarded against loss. Generally, the Degaussing Folder is in the possession of the navigator. The engineer officer provides the navigator with the names of engineering personnel who will require access to the folder.

The Ship's Force Degaussing Maintenance Record, NAVSHIPS 1009, is a record of the maintenance performed on the degaussing system by the ship's force. When completed, the forms are inserted in the Degaussing Folder.

BASIC OPERATION OF SHIPBOARD DEGAUSSING

A coil of wire with current passing through it will produce a magnetic field whose polarity and magnitude are dependent on the amount and direction of current flow. A shipboard degaussing installation consists of one or more of these coils in specific locations aboard ship and a means to control the magnitude and direction of the current through the coils. Compass-compensating equipment, consisting of compensating coils and control boxes, are also installed as a part of the degaussing system to compensate for the deviation effect of the degaussing coils on the ship's magnetic compasses.

DEGAUSSING COILS

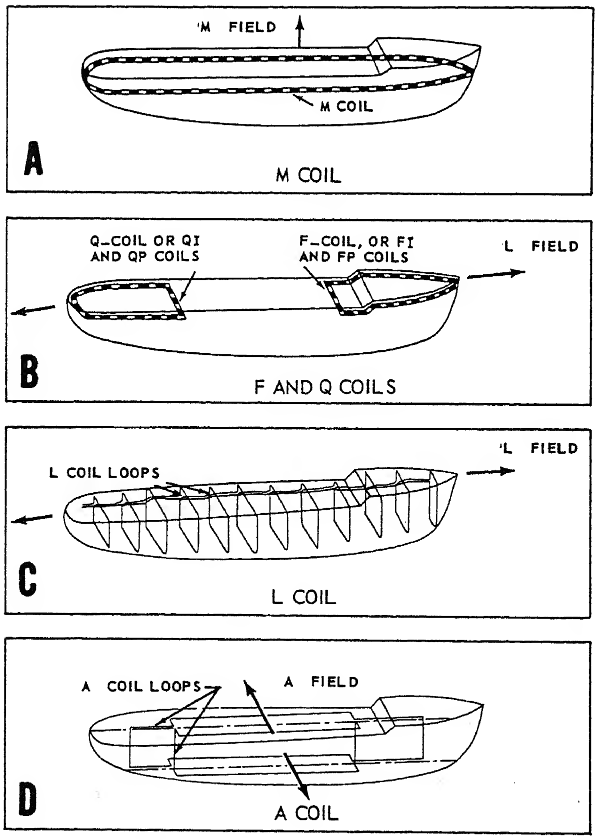
The distortion of the earth's field caused by the ship's permanent magnetization (vertical, longitudinal, and athwartship components) and the ship's induced magnetization (vertical, longitudinal, and athwartship components) is neutralized by means of degaussing coils. The degaussing coils are made with either single-conductor or multiconductor cables. The coils must be energized by direct current, which is supplied from 120-volt or 240-volt d.c. ship's service generators or from degaussing power supply equipment installed for the specific purpose of energizing the degaussing coils.

The degaussing coils consist of coils of cable wound on the ship, each having the correct location and the required number of turns to establish the required magnetic field strength when energized by direct current of the proper value and polarity. The coils will then produce magnetic field components equal and opposite to the components of the ship's field. Each coil consists of the main loop and may have smaller loops within the area covered by the main loop, usually at the same level. The smaller loops

oppose localized peaks that occur in the ship's magnetic field within the area covered by the main loop. The resultant effect of the degaussing coils, when the currents are properly set, restores the earth's field to the undistorted condition around the ship.

M Coil

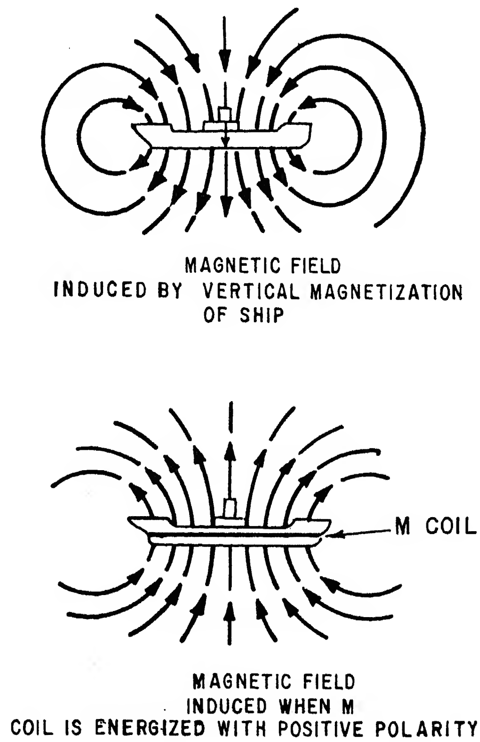
The M or main coil (fig. 6-4A) encircles the ship in a horizontal plane usually near the waterline. The M coil counteracts the magnetic field produced by the vertical permanent and the vertical induced magnetization of the ship (fig. 6-5). Hence, the M coil current must be changed when the ship changes magnetic latitude in order to keep the M coil field as nearly as possible equal and opposite to the field produced by the ship's vertical induced magnetization. The permanent vertical magnetization of a ship remains constant.



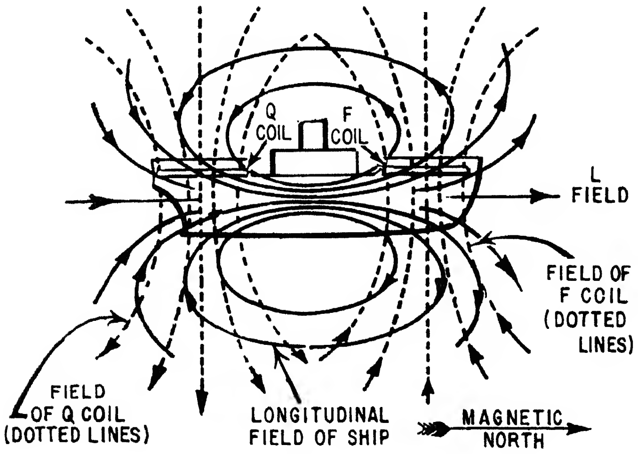
27.107
Figure 6-4.—Types of degaussing coils.

F and Q Coils

The F or forecastle coil (fig. 6-4B) encircl
the forward one-fourth to one-third of the sl
and is usually just below the forecastle
other uppermost deck; whereas, the Q or quarte
deck coil encircles the after one-fourth to or
third of the ship and is usually just below t
quarterdeck or other uppermost deck. The
and Q coils counteract the magnetic field pr
duced by the ship's longitudinal permanent a
longitudinal induced magnetization. The sha
of the magnetic field produced by the F anc
coils is somewhat different from the magne
field produced by the ship's longitudinal ma
netism, but, in general, the two fields are oppos
and directly below the bow and stern of the sl
(fig. 6-6). The F and Q coil currents must
changed when the ship changes its course
magnetic latitude in order to keep the c
strengths at the proper values to counteract t
changes in the ship's longitudinal induced ma
netization. Two adjustments are necessary, one
change the F coil current and the other to char



27.
Figure 6-5.—Effects of induced vertical magneti
and M coil magnetism.



27.370
Figure 6-6.—Longitudinal field of ship and neutralizing fields of F-Q coils.

the Q coil current. In many installations the conductors of the F and Q coils are connected to form two separate circuits designated as the FI-QI coil and the FP-QP coil (fig. 6-4B).

The FI-QI coil counteracts the magnetic field produced by the ship's longitudinal induced magnetization. The longitudinal induced magnetization changes when the ship changes heading or magnetic latitude, and the FI-QI coil current must be changed accordingly.

The FP-QP coil counteracts the magnetic field produced by the ship's longitudinal permanent magnetization. The longitudinal permanent magnetization does not change when the ship changes heading or magnetic latitude; therefore, no change is needed in the strength of the FP-QP coil.

L Coil

The L or longitudinal coil (fig. 6-4C) consists of loops in vertical planes that are parallel to the frames of the ship. The coil counteracts the magnetic field produced by the ship's longitudinal permanent and longitudinal induced magnetization. The L coil is more difficult to install than the F and Q coils or the FI-QI and FP-QP coils, but provides better neutralization because it more closely simulates the longitudinal magnetization of the ship. The L coil is commonly used in minesweeper vessels.

The longitudinal induced magnetization changes when the ship changes heading or magnetic latitude; therefore, the L coil current must be changed accordingly. Aboard a minesweeper, the L coil current must even be changed as the vessel pitches. Roll or pitch adjustments, or both, are necessary on all the degaussing coils aboard minesweepers.

A Coil

The A or athwartship coil (fig. 6-4D) consists of loops in vertical fore-and-aft planes. The A coil produces a magnetic field that will counteract the magnetic field caused by the athwartship permanent and athwartship induced magnetization. The athwartship induced magnetization changes when the ship changes heading or magnetic latitude; therefore, the A coil (current) must be changed accordingly.

MANUAL DEGAUSSING SYSTEMS

Degaussing installations, as previously stated, consist of different combinations of degaussing coils and manual or automatic degaussing equipment to control the current in these coils. The selected combination depends on the size and the intended use of the particular ship.

The current in the A coil and in the FI-QI or F and Q coils must be changed whenever there are changes in the ship's heading or in the magnetic latitude, or both. Current in the coils is controlled manually in the older installations and automatically in all newer installations. Current in the M and FP-QP coils remains essentially constant with the current in the M coil changing only when the ship changes zones and the current in the FP-QP coil changing only as a result of calibration.

Degaussing installations that control the coil currents manually are energized from constant voltage d.c. generators or from variable voltage motor-generators and are called rheostat and motor-generator installations, respectively.

Reversing switches are used to change the polarity of the coils, except when provision for the change has been made in the design of the rheostat of the constant voltage supply or in the generator control of the variable voltage supply.

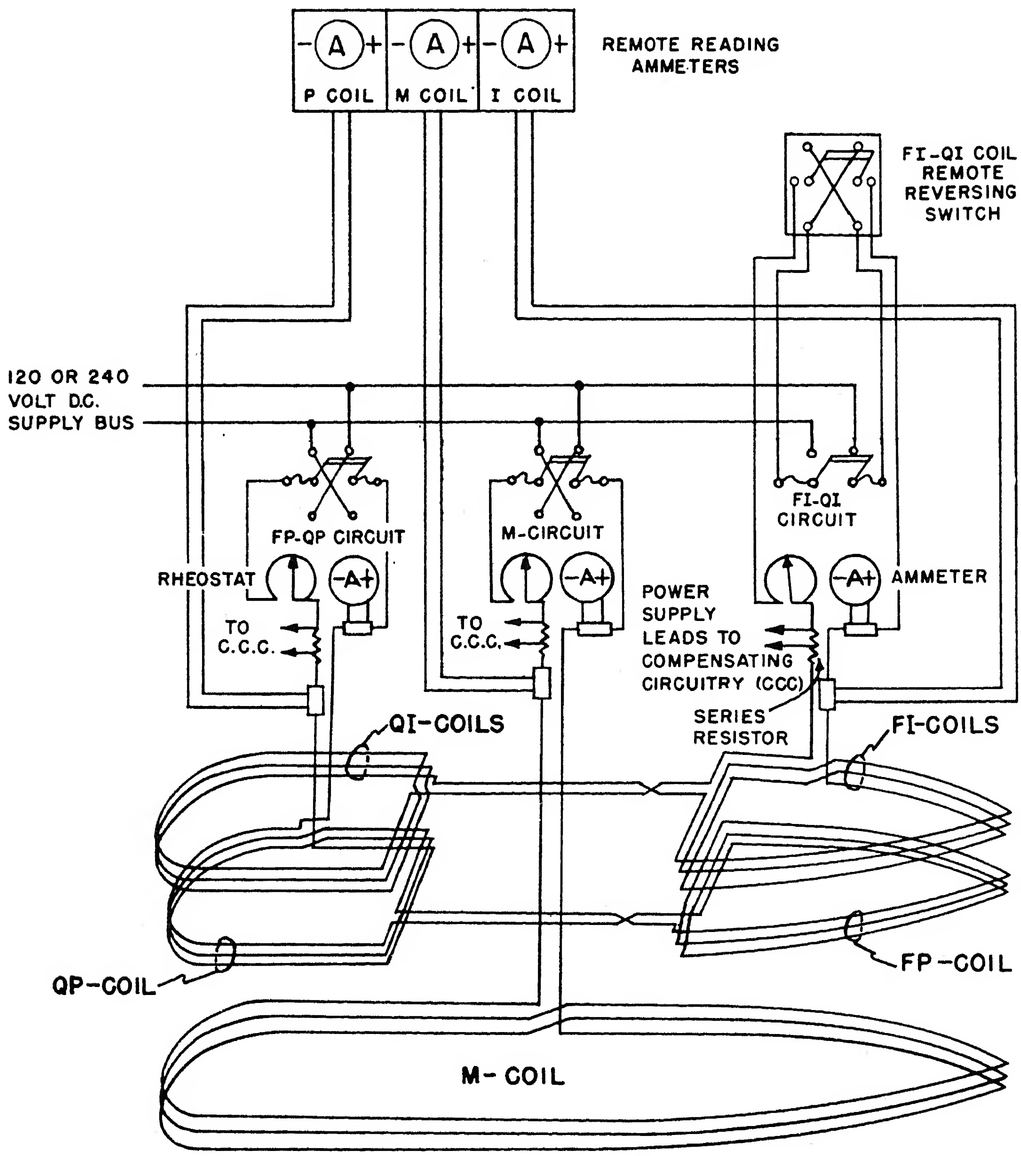
RHEOSTAT CONTROL

In a rheostat degaussing installation the power for the degaussing coils is supplied by a constant-voltage d.c. generator; the coil currents are controlled by adjusting a rheostat connected in series with the coil and power supply. An installation using rheostats to control the M,

FI-QI, and FP-QP coil currents is illustrated in figure 6-7. Some installations use manually operated rheostats while others use motor-operated rheostats. In the manual type, the rheostat is adjusted locally at the degaussing switchboard by turning the rheostat handle. In the motor-operated type, the rheostat shaft is turned by a motor which is controlled from a remote station by a push button. Motor-operated rheostats are equipped for manual operation the event of an emergency.

MOTOR-GENERATOR CONTROL

In a motor-generator degaussing installati the power for the degaussing coils is suppl by a motor-generator; the coil currents



77.

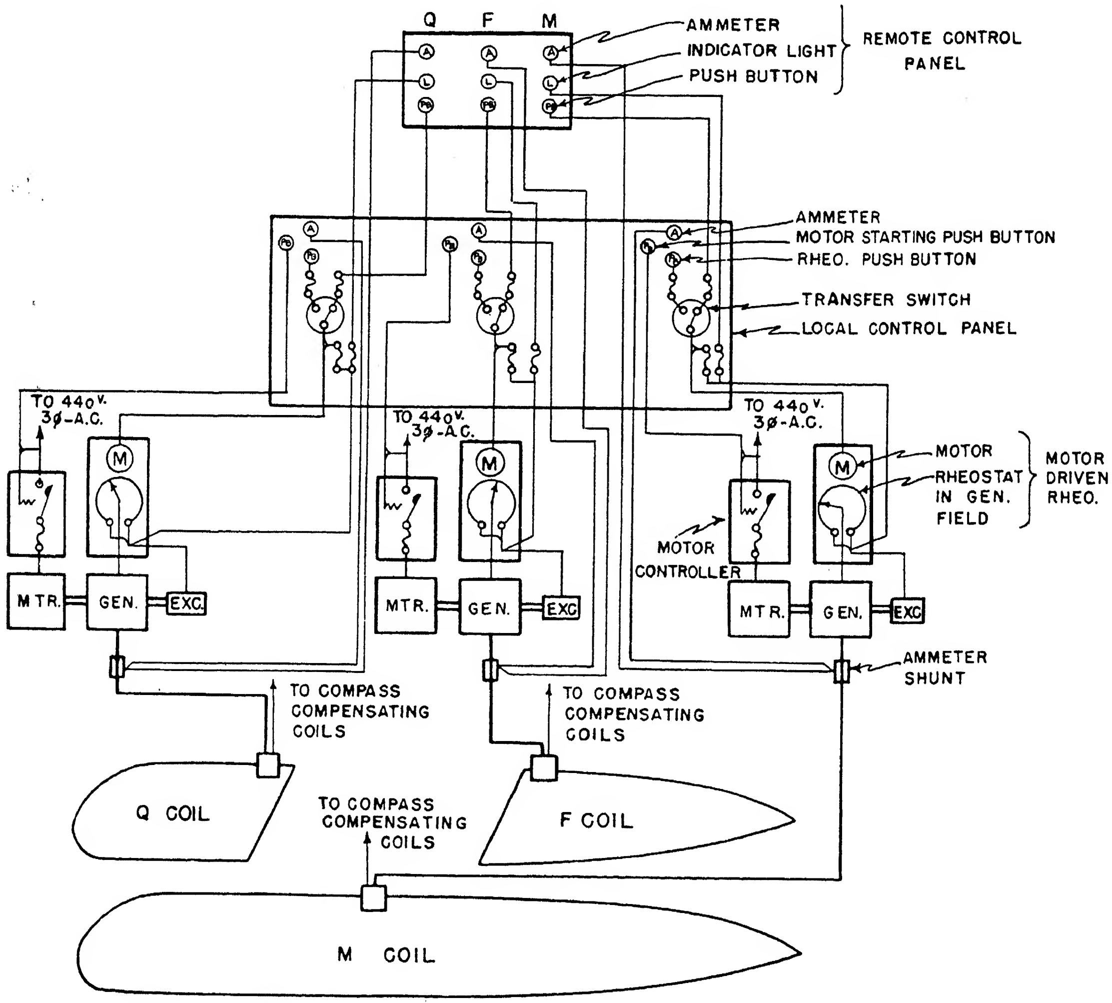
Figure 6-7.—Manual degaussing system with rheostat control.

controlled by adjusting a rheostat in the generator field circuit to vary the output of the generator. A single-line diagram of this type installation is illustrated in figure 6-8. The rheostats in the generator fields can be operated either manually or by a motor to change the generator voltage and thereby adjust the coil current to the desired value.

POLARITY

The polarity of the degaussing coil currents is of particular importance. If the polarity of any of the degaussing coils is incorrect, the ship may be in much greater danger from magnetic mines than if no degaussing were installed. The coils, instead of cancelling the magnetic field, would be adding to it. The polarity of a coil should be checked as to whether the pointer of the ammeter for the coil is on the POSITIVE (right) or NEGATIVE (left) side of the zero-center ammeter. Also, the polarity of a coil can be checked by observing whether the positive or negative plate glows in the neon indicator light for the coil. For positive polarity the right-hand electrode glows, and for negative polarity the left-hand electrode glows.

The direction of current (polarity) can also be checked by a degaussing polarity indicator or a small compass. The polarity indicator dial



77.182

Figure 6-8.—M, F, and Q coil installation with motor-generator control.

is marked to denote the direction of current. When taking polarity readings with the indicator or small compass, move the device toward the degaussing coil until a good deflection is obtained, and no closer. The needle in the indicator or compass will reverse its magnetic polarity if the device is held too closely to the coils. The indicator or compass should be checked after each test to ensure that the magnetic polarity of the needle has not reversed.

CHANGING COIL CURRENTS

The Degaussing Folder for each ship gives the current needed for each coil at all positions on the earth's surface and at all headings. One or more of the coil currents must be changed when one of the following conditions occurs:

1. When the ship passes from one Z zone to another.

The vertical intensity (Z component) of the earth's field, which is maximum at the magnetic poles and zero at the magnetic equator, is divided into a number of Z zones. The number of Z zones will vary, depending on the amount of compensation provided by the particular installation. Degaussing Chart No. 1 (fig. 6-9) illustrates the Z zones for the Atlantic and Indian Oceans. The reverse side of this chart (not shown) contains the same number of Z zones for the Pacific Ocean. The coil settings are filled in (lower left of chart) for the various zones after the ship has been ranged.

2. When the ship passes from one H zone to another.

The horizontal intensity (H component) of the earth's magnetic field, which is maximum at the magnetic equator and zero at the magnetic poles, is divided into a number of H zones. Similar to the Z zones, the number of H zones will vary, depending on the degree of compensation provided by the degaussing system. Degaussing Chart No. 2 (fig. 6-10) illustrates the H zones for the Atlantic and Indian Oceans and the reverse side (not shown) contains the same number of H zones for the Pacific Ocean.

3. When the ship's heading changes from one sector to another.

The entire range of headings from 0° to 360 is divided into a number of sectors, each covering a part of the whole range of courses.

The Degaussing Course Corrections Setting Diagram No. 1 for the FI-QI coil and Diagram No. 2 for the FI-QI and A coils are illustrated respectively in figures 6-11 and 6-12.

The Degaussing Course Correction Setting Table No. 1 for the F and Q coils and Table No. 2 for the F, Q, and A coils are illustrated respectively in figures 6-13 and 6-14.

None of the degaussing coil currents are changed as long as the course remains in one sector, that is, the Z zone and H zone remain unchanged. The FP-QP coil current is NOT changed when the ship's heading or the ship's position changes. The following changes are necessary when changing from one sector to another or from one zone to another:

1. The M coil current must be changed when the ship moves from one Z zone to another. The M coil current is NOT changed when the ship moves from one H zone to another or when the heading changes from one sector to another.

2. The F, Q, FI-QI, L, and A coil currents are not changed when the ship moves from one Z zone to another, but must be changed when the ship moves to a different H zone, or when the heading changes to a different sector.

AUTOMATIC DEGAUSSING SYSTEMS

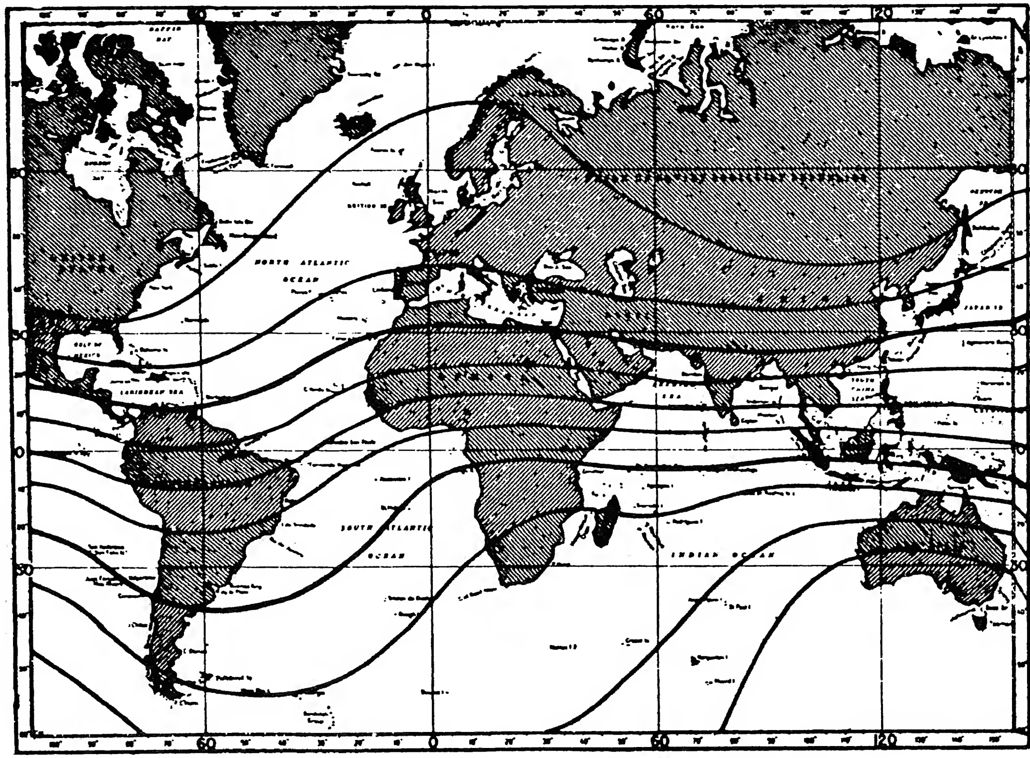
As we have discussed, current changes are necessary to produce the correct strength of magnetism at different headings. You can imagine how very time consuming, with inescapable human error, it would be if personnel had to make the calculations for the current changes and take

ATLANTIC-INDIAN OCEAN

DEGAUSSING CHART Nº 1.

FOR AREAS WEST OF 105° WEST AND EAST OF 155° EAST SEE PACIFIC CHART (OVER)

CLASSIFICATION



COIL SETTINGS+ OR VALUES IN NUMBERS, AMPERES, AMPERE-TURNS. *				REGIONS	Z ZONE
		FP-QP			
97.5				NORTHERN	.55
84.0		15			.44
70.5					.33
57.0				MIDDLE	.22
43.5					.11
30.0		15			.00
16.5					-.11
3.0				SOUTHERN	-.22
-10.5					-.33
-24.0		15			-.44
-37.5					-.55
13.5				M STEP	

ATLANTIC-INDIAN OCEAN

* STRIKE OUT WHATEVER IS NOT APPLICABLE

INFORMATION FOR ISSUING PERSONNEL ONLY, NOT FOR SHIP'S USE

Initial Calibration. Z --; H --; b 58;
D 64; Dr 21/25; NM 9; N&S runs; M-Step
based on OP 1538 Para 315 ("m" unknown);
Post Deperm

SHIP (Name, Type and No., AND Nation) USS - -

PORT OF ISSUE USN DEG FACILITY DATE 2 May 1969

SIGNATURE OF ISSUING OFFICER Lt. C. Cox

(Supersedes NAVWEPS 8950/46A) + *Settings apply to spaces between lines, not to lines.*

NAVSHIPS 8950/14A (REV. 3-67)
DG NO. 8

CLASSIFICATION AND GROUP MARKING

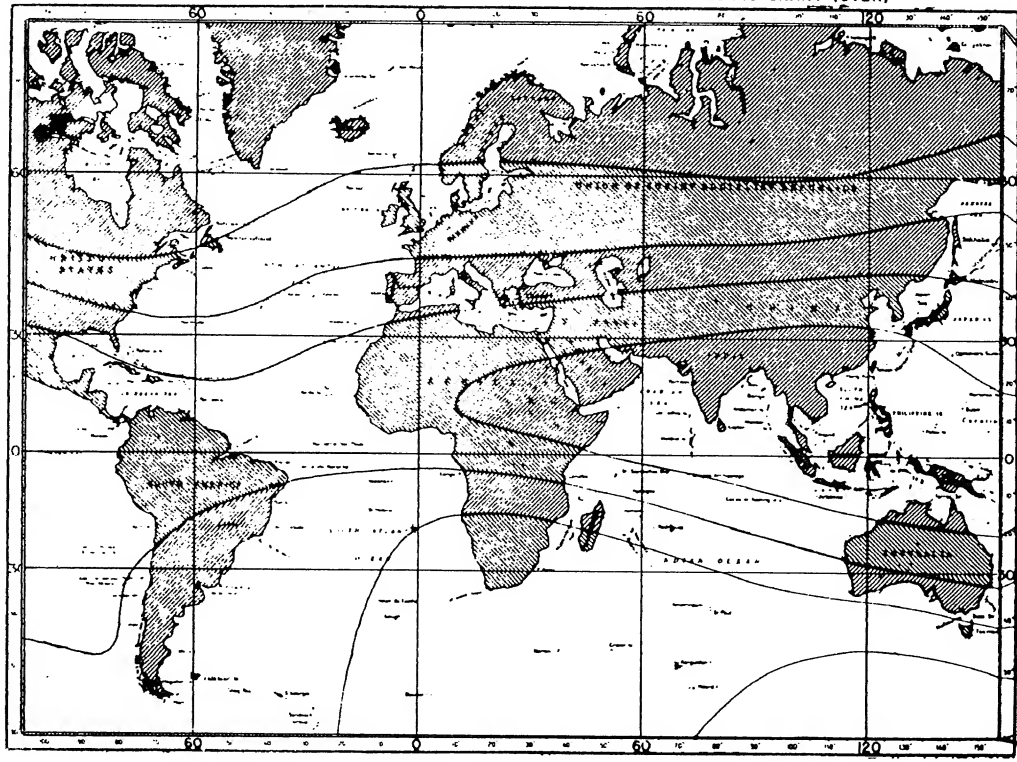
69.14

Figure 6-9.—Degaussing chart No. 1.

ATLANTIC-INDIAN OCEAN

DEGAUSSING CHART № 2.

FOR AREAS WEST OF 105° WEST AND EAST OF 155° EAST SEE PACIFIC CHART (OVER)



MANUAL OPERATION

COIL SETTINGS IN AMPERES			H
FI-QI			ZONE
6.7	SEE ALSO DEGAUSSING COURSE CORRECTION SETTING DIAGRAM NO. 1		.115
10.0			.175
13.3			.235
16.7			.295
20.0			.355
16.7			.295
13.3			.235
10.0			.175
6.7			.115

ATLANTIC-INDIAN OCEAN

* STRIKE OUT WHATEVER IS NOT APPLICABLE

† Settings apply to spaces between lines, NOT to lines.

INFORMATION FOR ISSUING PERSONNEL ONLY, NOT FOR SHIP'S USE

Initial Calibration; Z__, H__; B 58;

D 64; Dr 21/25; I based on N-S runs.

(NAME, TYPE AND NO., AND NATION)

SHIP * USS ________________

PORT OF ISSUE USN DEG FACILITY DATE 2 May 69

SIGNATURE OF ISSUING OFFICER Lt. C. Cox

(Supersedes NAVWEPS 8950/46B)

NAVSHIPS 8950/14B (REV. 3-67)
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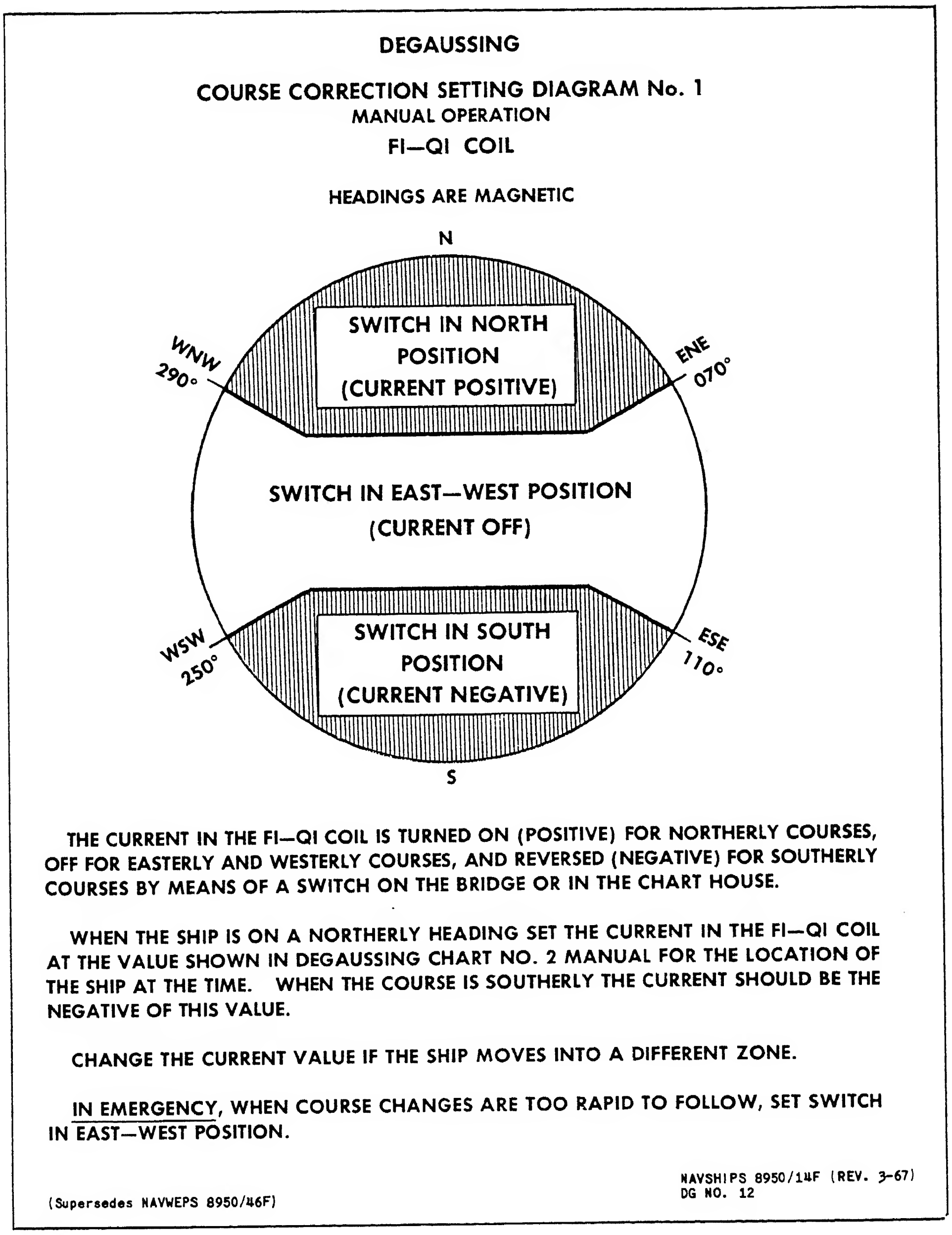


69.16

Figure 6-11.—Degaussing course correction setting diagram No. 1.

corrective action. To eliminate these disadvantages, a control system was designed to utilize the primary course indicating equipment already aboard ship, the gyrocompass, in conjunction with the degaussing coils. This system is the automatic degaussing system.

There are many types of automatic degaussing systems but they all use the same basic concepts of operation. We shall describe the SSM system which differs from older systems by the manner in which the current is controlled and sent to the degaussing coils. The SSM uses solid state

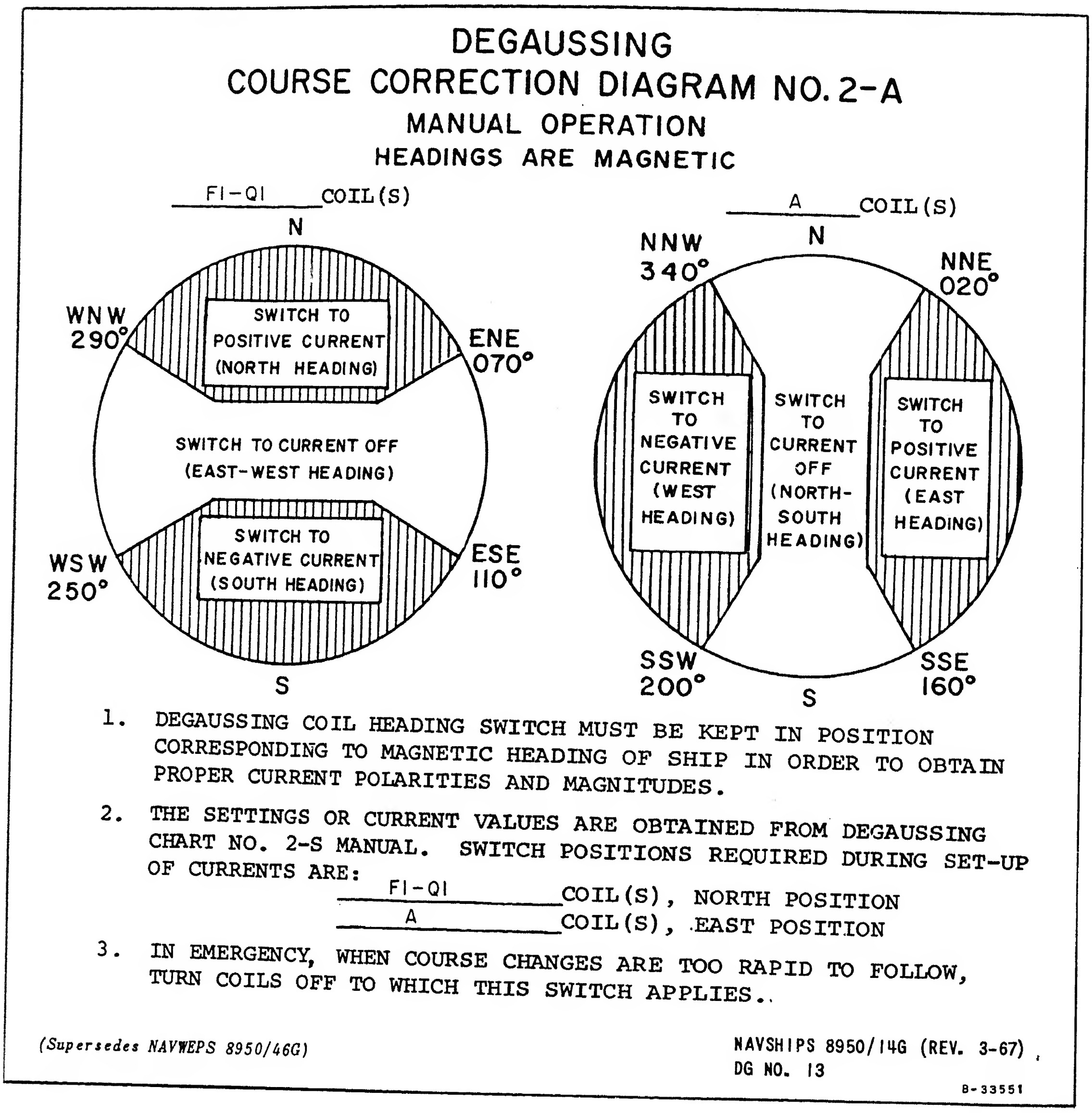


Figure 6-12.—Degaussing course correction setting diagram No. 2. 69.170

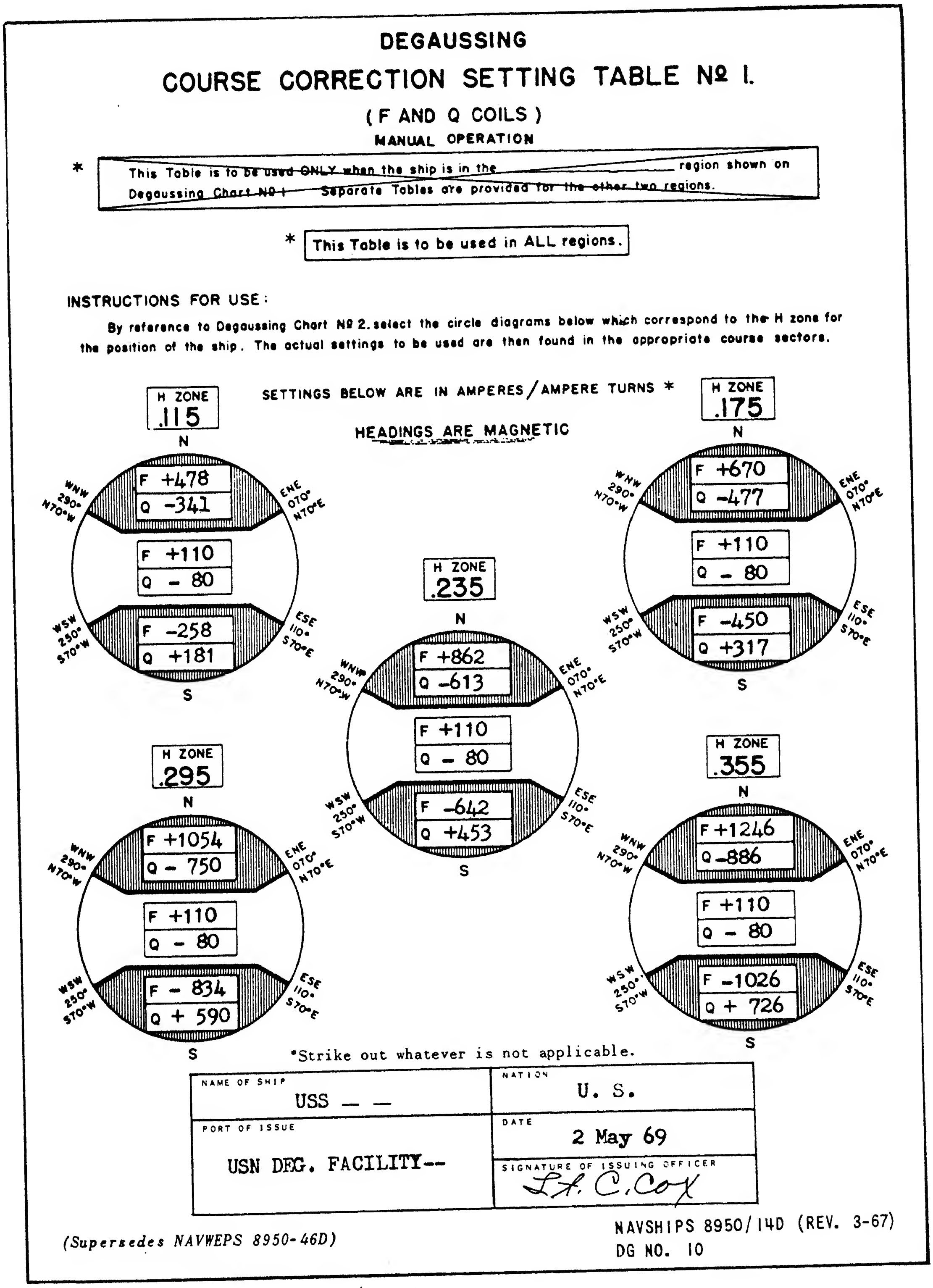
devices rather than the magnetic amplifiers in older types.

SSM AUTOMATIC DEGAUSSING SYSTEM

The SSM automatic degaussing system controls the current in four independent degaussing coils. The system (fig. 6-15 and 6-16) is made up of the degaussing switchboard, FI-QI coil power supply, FP-QP coil power supply, A coil power supply, M coil power supply, and a remote control unit.

Degaussing Switchboard

The degaussing switchboard receives 450 VAC from ship's power and generates a reference signal, proportional to the ship's position and heading, which controls the output of each coil power supply.



DEGAUSSING

COURSE CORRECTION SETTING TABLE Nº 1.

(F AND Q COILS)

MANUAL OPERATION

* ~~This Table is to be used ONLY when the ship is in the ____ region shown on Degaussing Chart Nº 1. Separate Tables are provided for the other two regions.~~

* This Table is to be used in ALL regions.

INSTRUCTIONS FOR USE:

By reference to Degaussing Chart Nº 2. select the circle diagrams below which correspond to the H zone for the position of the ship. The actual settings to be used are then found in the appropriate course sectors.

SETTINGS BELOW ARE IN AMPERES/AMPERE TURNS *

HEADINGS ARE MAGNETIC

*Strike out whatever is not applicable.

NAME OF SHIP	NATION
USS — —	U. S.
PORT OF ISSUE	DATE
USN DEG. FACILITY--	2 May 69
	SIGNATURE OF ISSUING OFFICER
	Lt. C. Cox

(Supersedes NAVWEPS 8950-46D)

NAVSHIPS 8950/14D (REV. 3-67)
DG NO. 10

69.17D

Figure 6-13.—Degaussing course correction setting table No. 1.

DEGAUSSING
COURSE CORRECTION SETTING TABLE NO. 2
(F, Q, AND A COILS)

MANUAL OPERATION

* This Table is to be used ONLY when the ship is in the NORTHERN region shown on Degaussing Chart No. 1. Separate Tables are provided for the other two regions.

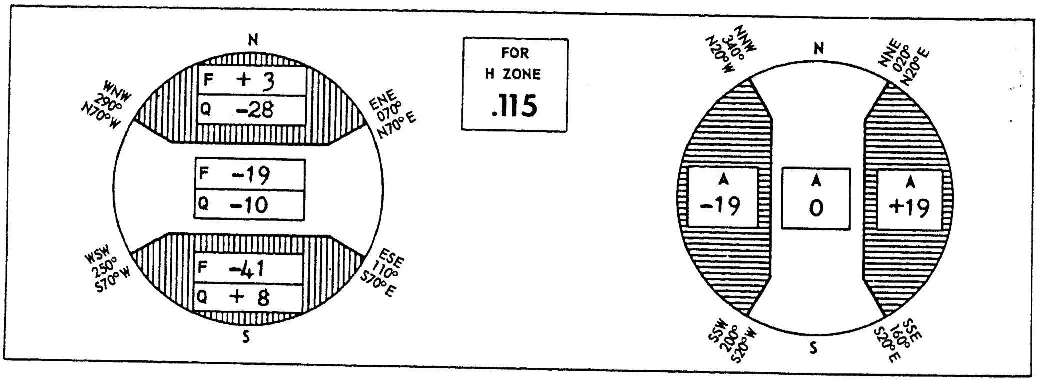
* This Table ~~is to be used in~~ ALL regions.

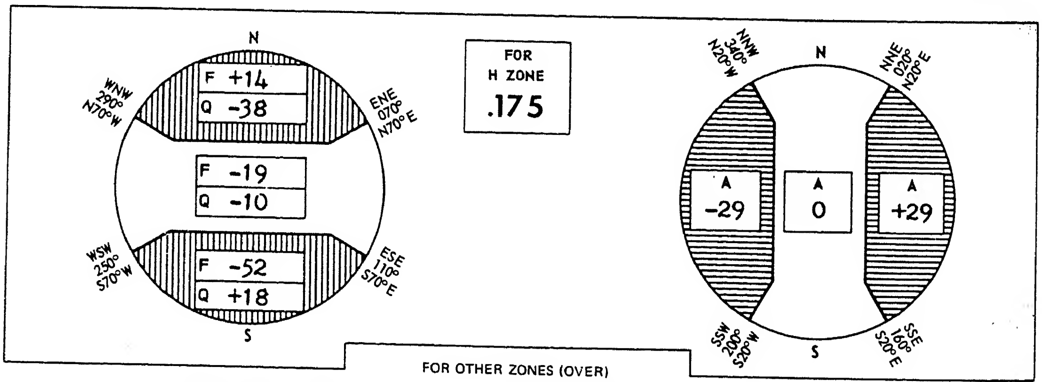
INSTRUCTIONS FOR USE:

By reference to Degaussing Chart No. 2 select the circle diagrams below which correspond to the H zone for the position of the ship. The actual settings to be used are then found in the appropriate course sectors.

SETTINGS BELOW ARE IN AMPERES/~~AMPERE TURNS~~*
HEADINGS ARE MAGNETIC

AP = 0





FOR OTHER ZONES (OVER)

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PORT OF ISSUE	DATE
USN DEG. FACILITY - -	2 May 1969
	SIGNATURE OF ISSUING OFFICER
	L.C. Cox

*Strike out whatever is not applicable.

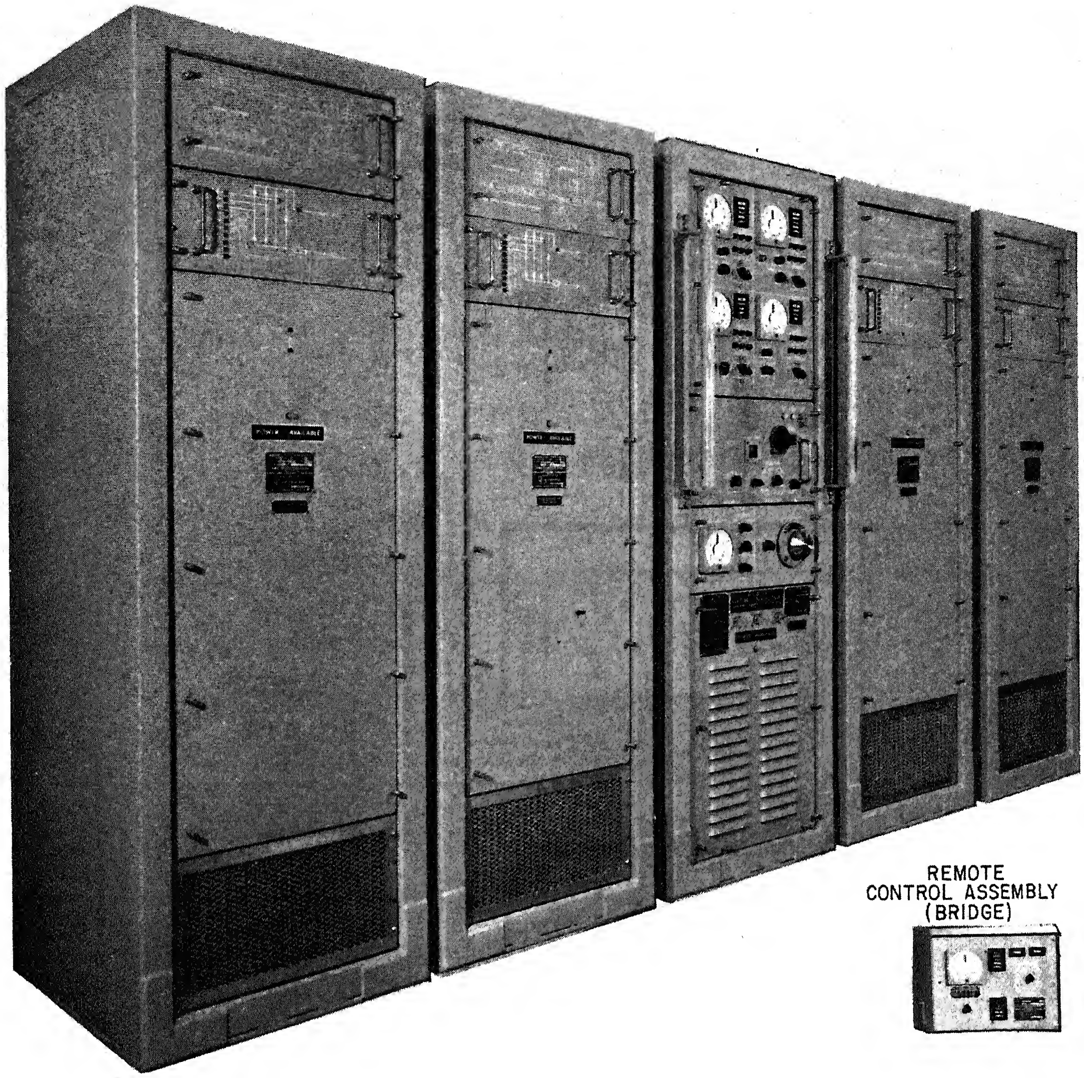
(Supersedes NAVWEPS 8950/46E)

NAVSHIPS 8950/14E (REV. 3-67) (FRONT)
DG NO. 11

B-33549

69.171

Figure 6-14.—Degaussing course correction setting table No. 2 (Front).



27.371X

Figure 6-15.—SSM Automatic Degaussing System.

Manual Channels (M & FP-QP)

The manual channels, M and FP-QP, located in the degaussing switchboard, generate a reference signal by applying 24 VDC to the induced magnitude potentiometer shown in darkened line on figure 6-17. The wiper arm on the potentiometer is adjusted to obtain the desired signal in accordance with the ship's Degaussing Folder. The polarity is selected by the position of the manually operated polarity switch. Only the M coil channel is shown in figure 6-17.

Automatic Channels (A & FI-QI)

The two automatic channels, A and FI-QI, also located in the degaussing switchboard, are identical with the exception of a permanent bias current that can be applied to the A coil and not to the FI-QI (fig. 6-18). The permanent bias current

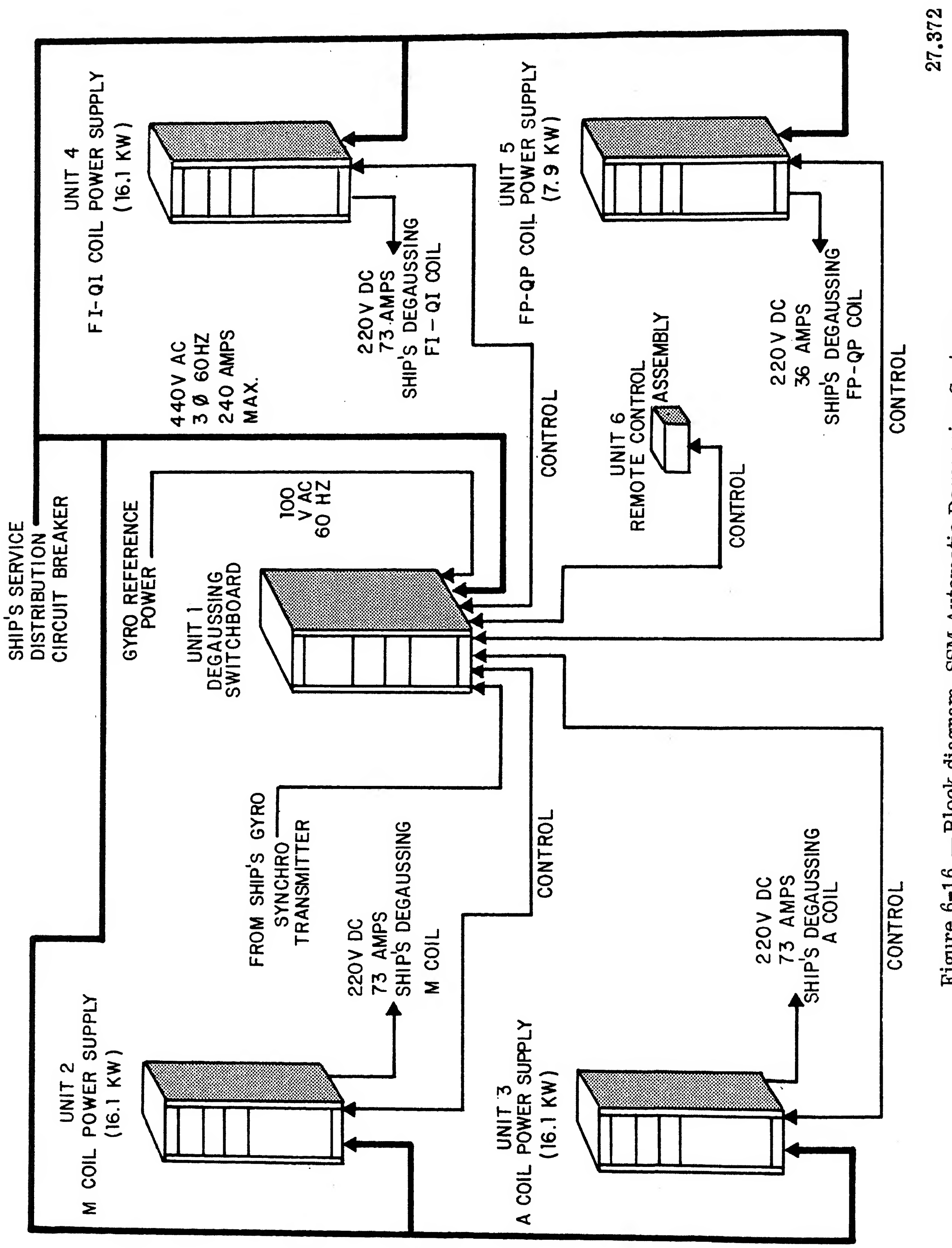
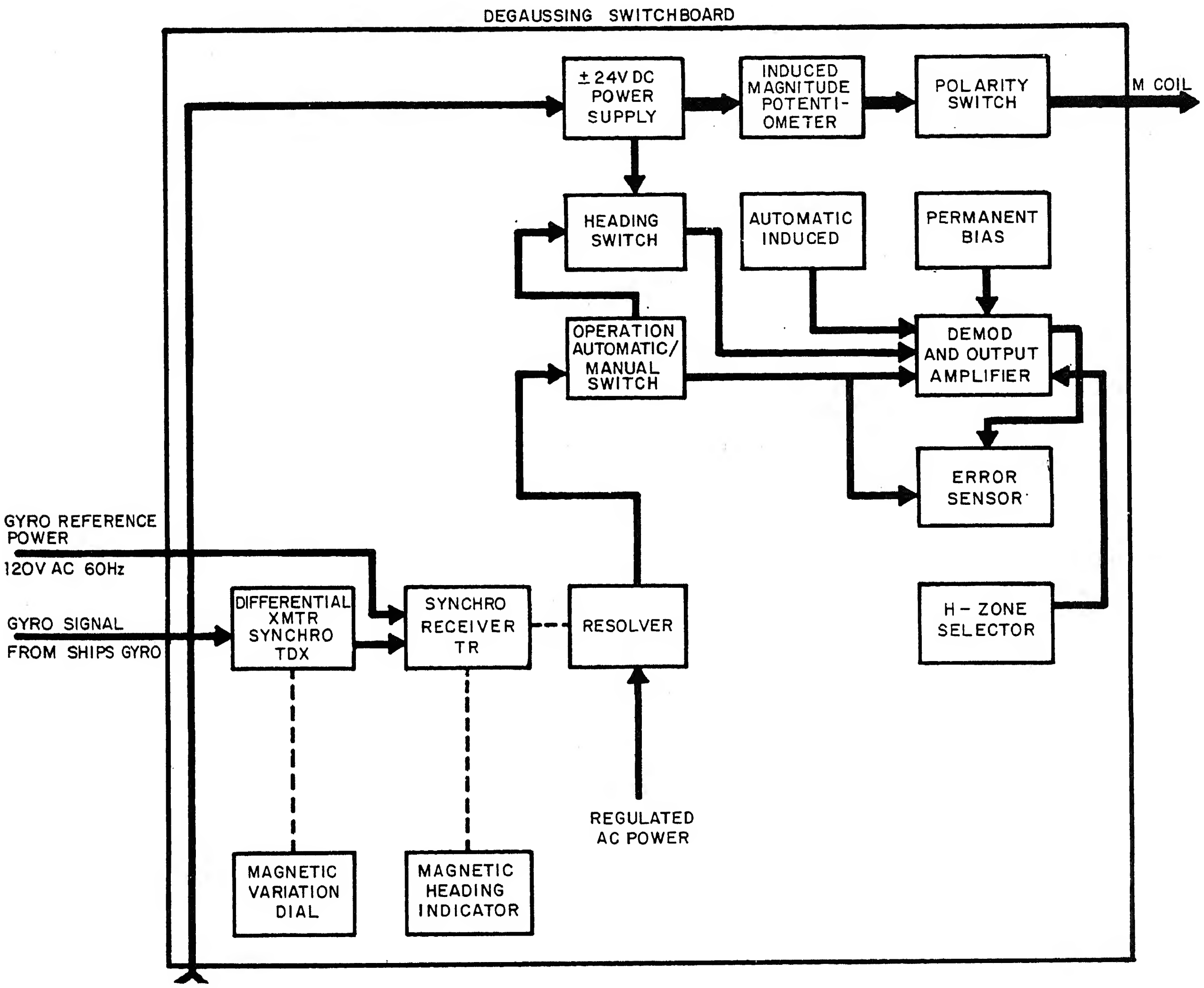


Figure 6-16.—Block diagram, SSM Automatic Degaussing System.



27.373

Figure 6-17.—Manual Channel (M coil).

compensates for the permanent athwartship component of the ship's magnetism. The setting of the permanent bias is found in the ship's Degaussing Folder.

When either or both of the automatic channels are switched to the manual mode, the reference signal, magnitude, and polarity are determined by the setting of the heading switch.

Figure 6-19 shows the A coil only. In the automatic mode a signal is applied to the differential transmitter synchro TDX, which modifies the true heading signal. The magnetic variation dial is manually operated to adjust the magnetic heading signal in accordance with the known magnetic variation for the particular area in which the ship is operating. The magnetic signal is then applied to the synchro

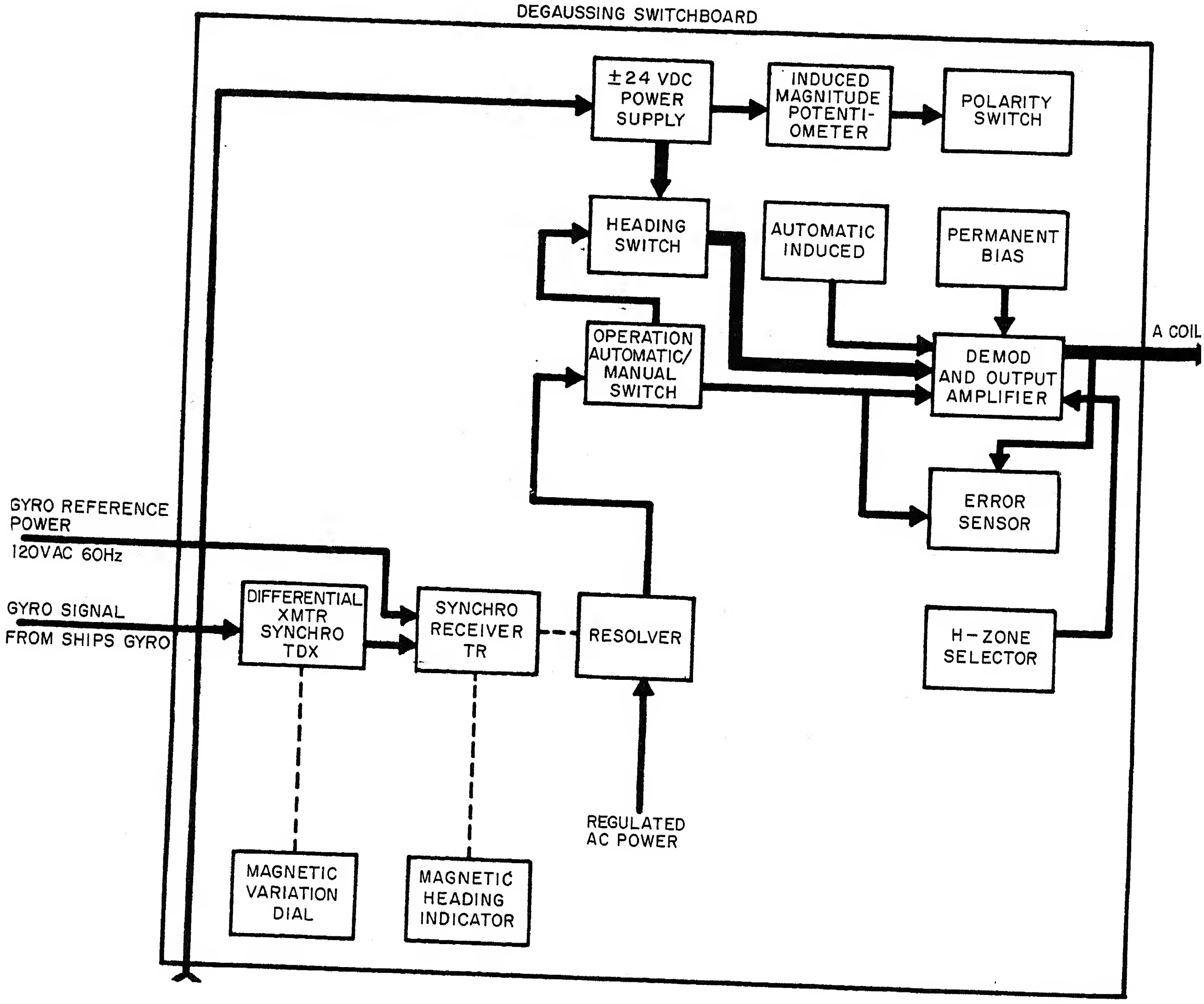


Figure 6-18.—Automatic channel, manual operation. 27.374

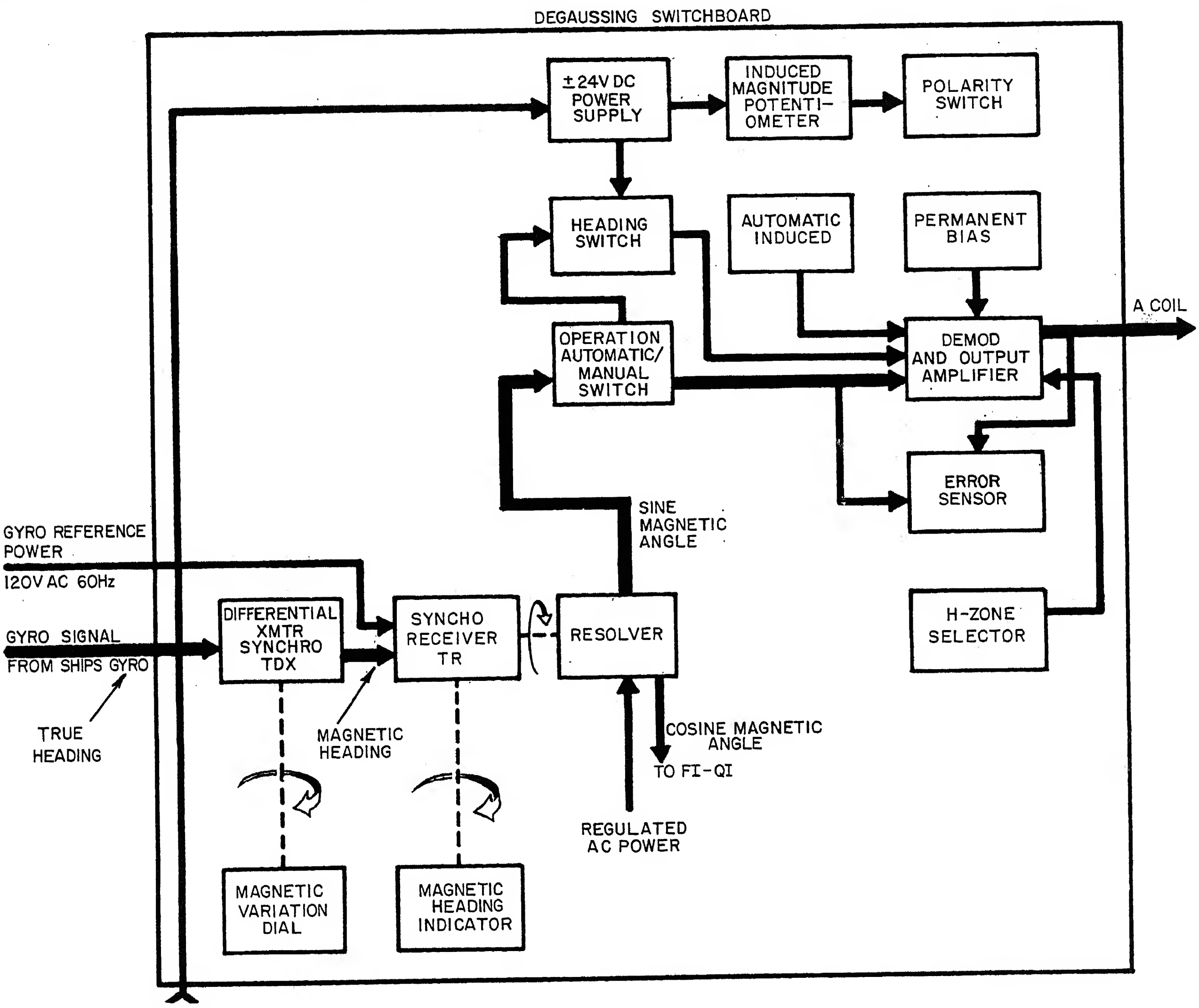
receiver TR, which will turn the magnetic heading indicator and the resolver. The resolver breaks the magnetic heading signal into two separate signals, one representing the sine, the other the cosine of the magnetic heading angle. The sine signal is used for the A coil, the cosine for the FI-QI coil. The automatic induced potentiometer establishes the maximum level to be operated in the automatic mode. Also fed into the demodulator and output amplifier are the permanent bias (for the "A" channel only) and the H-zone setting. An error sensor also compares the input and output signals to the demodulator. Any difference will activate an error signal light on the degaussing switchboard.

The four reference signals that are developed by each coil channel are supplied to the corresponding power supply.

Coil Power Supplies

The coil power supplies contain silicon controlled rectifiers. You will find a discussion on the workings of these devices helpful in understanding the operation of the power supplies.

An SCR is a semiconductor device which can be gated (turned on) during any portion of the



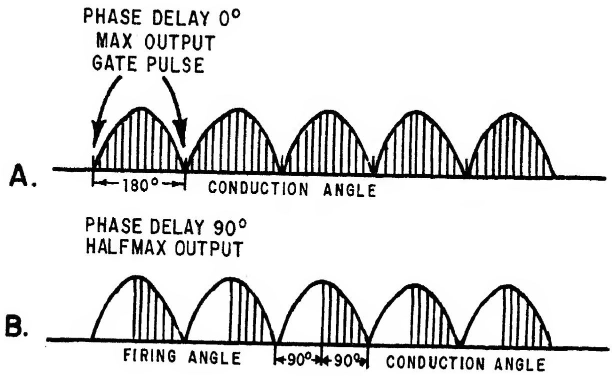
27.375

Figure 6-19.—Automatic channel, automatic operation (A coil only).

positive half-cycle of an a.c. signal. Refer to figure 6-20A. If the gate pulse fires at the start of the half-cycle, the SCR will continue to conduct during the entire half-cycle. If the gate pulse fires 90° later (fig. 6-20B), the SCR will conduct on only half of the half-cycle. Therefore, we can control the firing rate of the SCR's by controlling the gate pulse and thereby control the output with a small signal.

This concept is used in the SSM degaussing coil power supplies. Please note in figure 6-21 that the signal developed by the channel in the degaussing switchboard goes through an isolation amplifier to electrically isolate it from the switchboard and the other three coil power supplies. The signal then goes to a regulator which also receives a current feedback signal from the coil. The signals are compared and then sent to the firing logic circuits. The firing logic circuits control the basic firing angle for the SCR's to control the output current. An error sensor compares the input and output signals in the same manner as the error sensor in the degaussing switchboard.

Two other types of automatic degaussing systems installed aboard ships are the GM-1A and the SM-9A. The basic principles of operation



27.376
Figure 6-20.—Operation of silicon control rectifier.

are the same as for the SSM, therefore, we sl give only a brief description of the two syste

GM-1A AUTOMATIC DEGAUSSING SYSTEM

The GM-1A automatic degaussing syst consists of nine units; a degaussing switchboa an automatic control unit (installed in the swit board), a degaussing remote control panel, rectifier power supplies (M coil and FP- coil power supplies), two motor-generator s (FI-QI coil and A coil), and two magnetic c trollers which are used only with the A c and FI-QI respectively. As illustrated in fig 6-22, the FP-QP coil power supply may either of two sizes, 3 kW or 5 kW, having differ

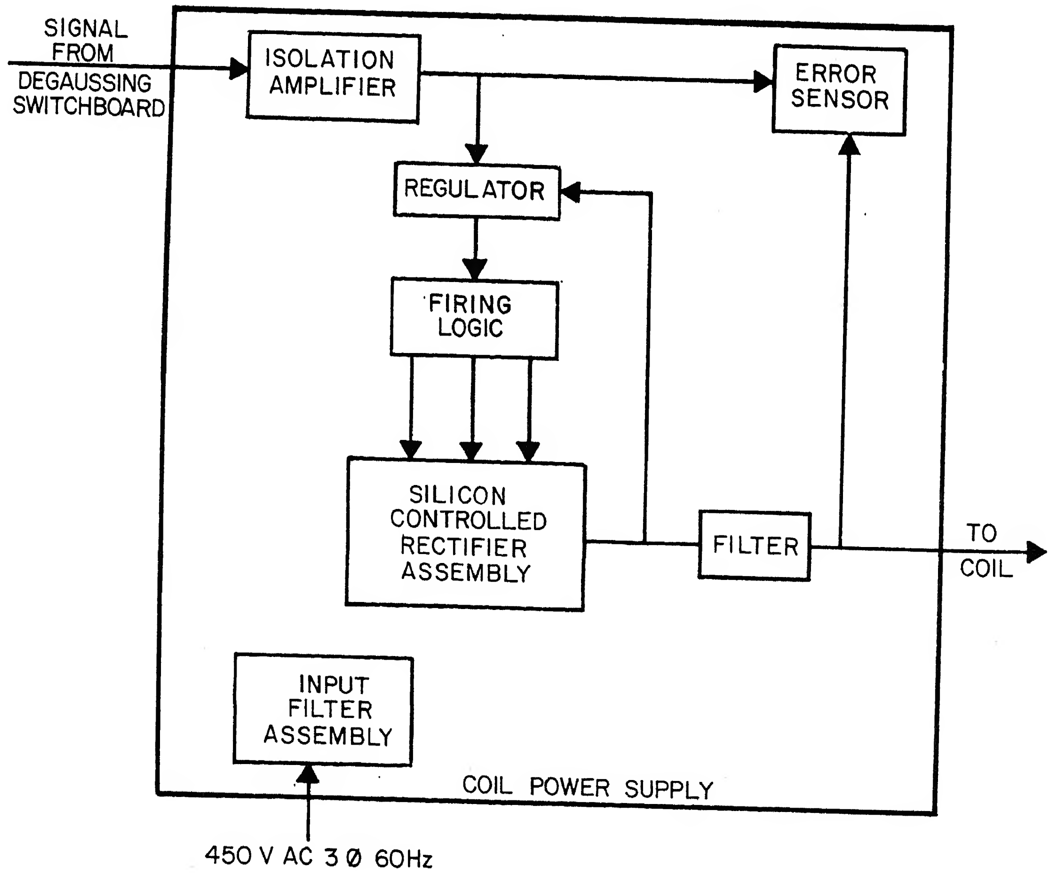
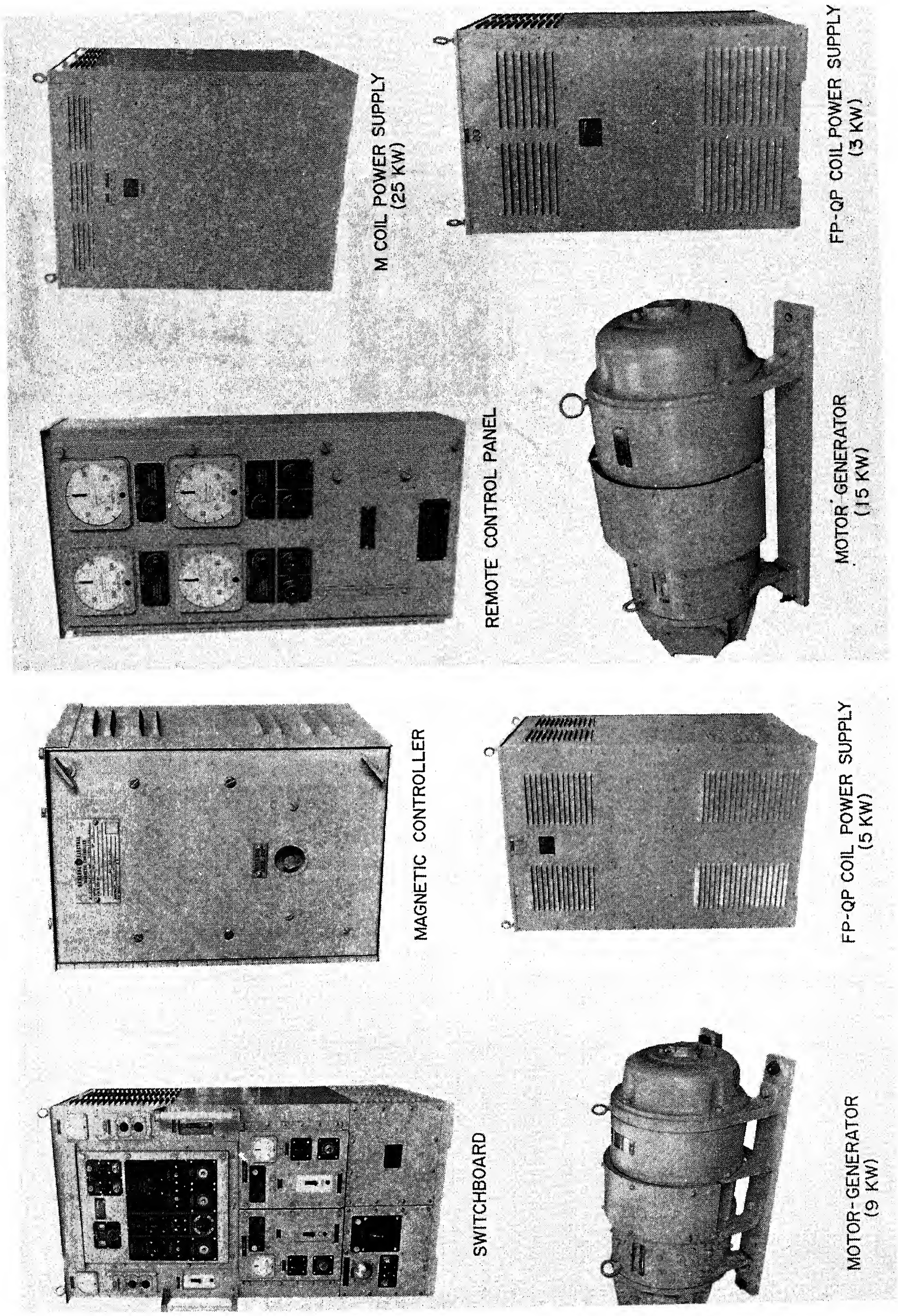


Figure 6-21.—Coil power supply.

27.377

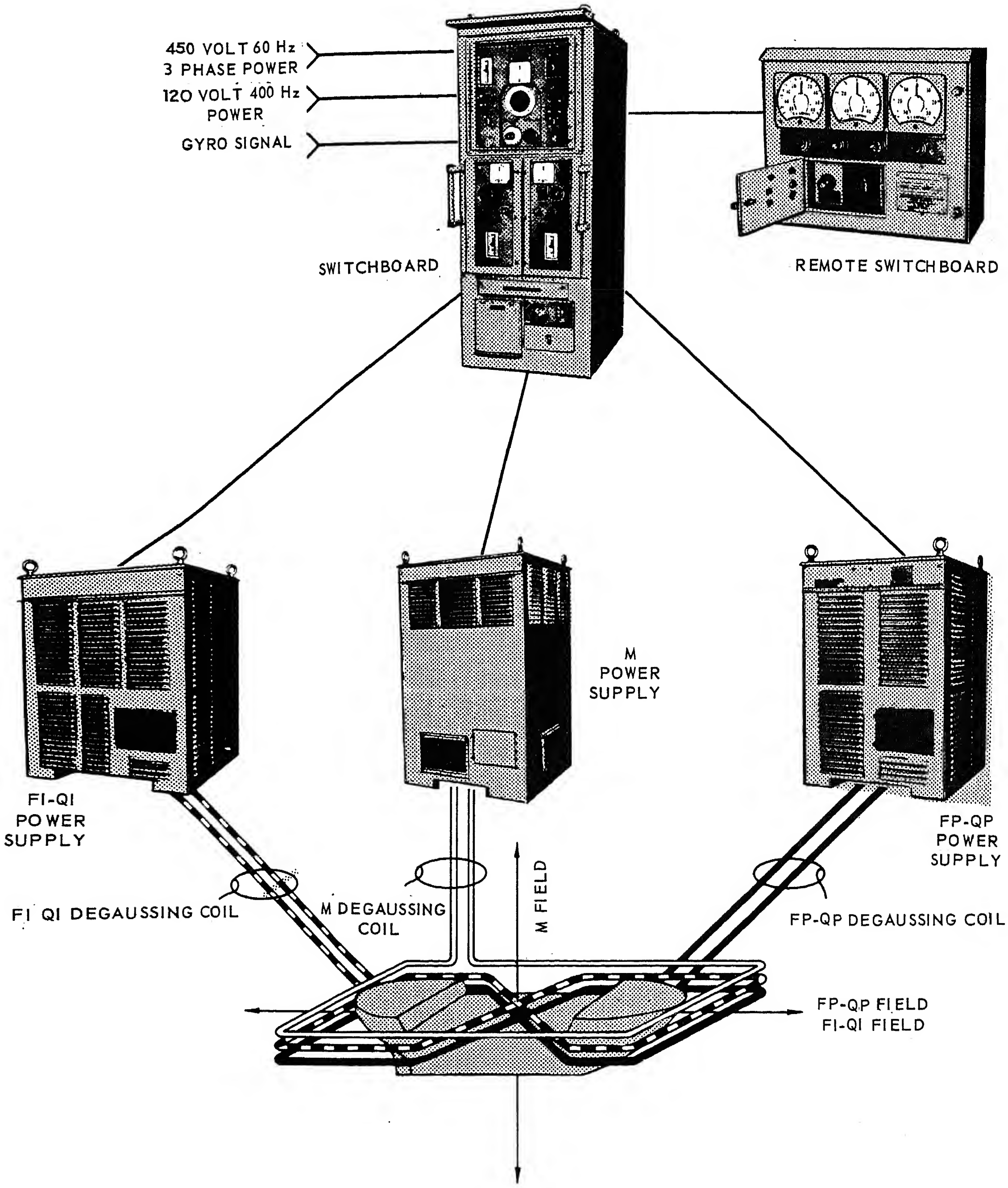


111.38

Figure 6-22.—Automatic control and power supply equipment.

output ratings. The A coil generator may likewise be either of two different sizes, 9 kW or 15 kW, having different output ratings.

The system provides automatic degaussing currents for the FI-QI coil and the A coil, and manually metered (nonautomatic) currents for the M coil and the FP-QP coil. In case the automatic equipment fails, the FI-QI and the A coil can also be controlled manually (Emergency Manual).



77.327

Figure 6-23.—Type SM-9A automatic degaussing control system.

SM-9A AUTOMATIC DEGAUSSING SYSTEM

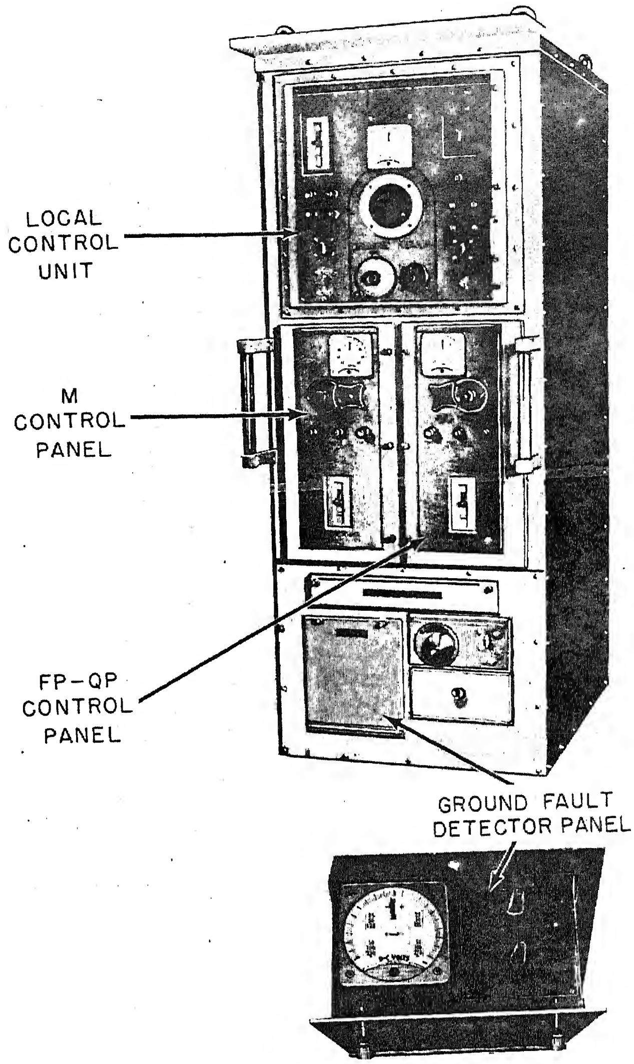
The SM-9A automatic degaussing control system comprises a degaussing switchboard (fig. 6-23), a remote switchboard, and FI-QI coil power supply, an FP-QP coil power supply, and an M coil power supply.

Degaussing Switchboard

The degaussing switchboard (fig. 6-24) contains the controls required to operate the degaussing system. The FI-QI control panel mounted at the top of the switchboard contains all the circuits required to control the FI-QI degaussing currents in both the manual and automatic modes of operation. The M control panel mounted in the center left section of the switchboard contains the controls and circuitry required to control the M coil current. The FP-QP control panel mounted center right contains the controls for setting the FP-QP coil current. At the bottom is located the power supply overheating alarm circuits and ground fault detector.

The remote control unit has three meters which indicate the current in each of the three degaussing coils. Three red lights mounted on the unit indicate whether there is trouble in any of the three circuits. One white light indicates that the system is in manual operation, and another indicates that the FI-QI current is being controlled at the remote control unit by the manual control switch on the remote unit.

The three power supplies contain the circuits necessary to supply the currents to degauss the ship. The only externally mounted components on the power supplies are indicator type fuses which fuse the power circuits in the supplies.



111.121
Figure 6-24.—Degaussing switchboard.

CHAPTER 7

AUXILIARY SHIPBOARD EQUIPMENT

Personnel assigned to the electrical division(s) maintain a variety of auxiliary equipment. Much of this equipment is vital to the ship's operation, and much of it is very complex in nature. In this chapter we shall discuss the basic operating principles of some of this equipment.

BATTERIES

Many types of equipment aboard ship utilize batteries as their source of direct current electricity. Such equipment includes portable announcing equipment, portable and emergency lighting equipment, ship's boats, dial telephone systems, gyrocompass systems, and many others. In some instances batteries are used as the only source of power, while in others, they are used as a secondary or standby power source.

A battery consists of one or more cells connected together to function as a source of electrical power.

PRIMARY CELL

A primary cell consists of two dissimilar materials (electrodes) immersed in acid. As a broad definition, a primary cell is one in which the chemical action eats away one of the electrodes, usually the negative. When this happens, the electrode must usually be replaced or the cell must be discarded. The dry cells employed in flashlights are common examples of primary cells.

SECONDARY CELL

Generally, a secondary cell is one in which the electrodes and the electrolyte are altered by the chemical action that takes place when the cell delivers current. These cells may be restored to their original condition by forcing an electric current through them in the direction opposite to that of discharge. The automobile storage battery is a common example o secondary cell.

Cells are connected together to provide amount of voltage and current required of battery. As an example, the common 12-v automobile battery consists of 6 cells, ea cell producing approximately 2 volts.

TYPES OF BATTERIES

There are many different types of batteri in use today, however, most of them are us in special applications and are not commor found in shipboard electrical equipment.

The dry cell, lead-acid and nickel-cadmiu batteries are by far the most common types use aboard ship today. The material present in this chapter, though not all inclusive, pro vides the reader with a general view of thes various types of batteries.

Dry Cell

The common carbon-zinc dry cell batter so-called because its electrolyte is not in liquid state, is used in flashlights and battl lanterns. Actually, the electrolyte is a mois paste. If it should become dry, it could n longer transform chemical energy to electrica energy. The name dry cell, therefore, is no strictly technically correct.

CONSTRUCTION OF THE DRY CELL.—The construction of a common type dry cell is shown in figure 7-1. The internal parts of the cell are located in a cylindrical zinc container which also serves as the negative electrode of the cell. A carbon electrode is located in the center and serves as the positive terminal of the cell. The paste electrolyte is a mixture of several substances. Its composition may vary, depending on its intended use and manufacturer,

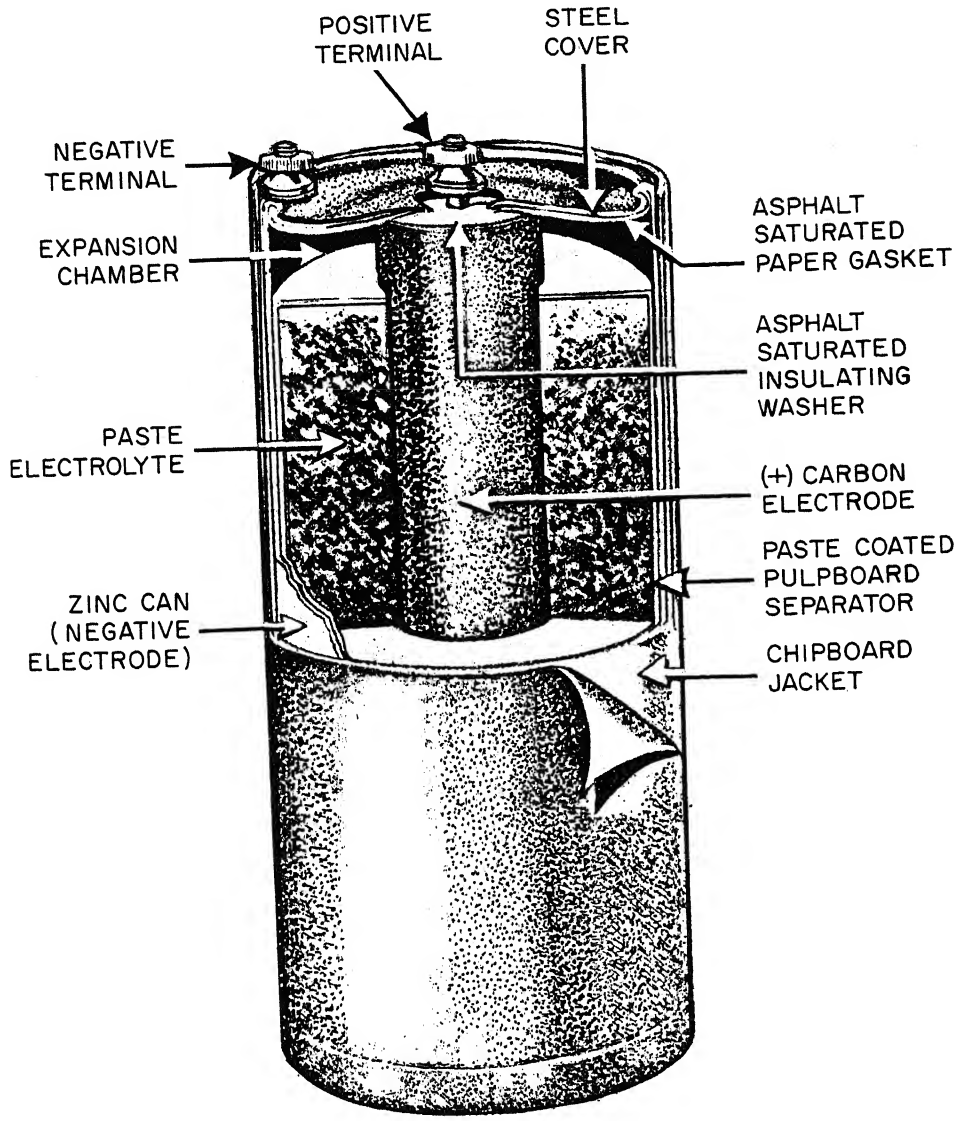


Figure 7-1. — Cutaway view of a dry cell.

Binding posts are attached to the electrodes so that wires may be conveniently connected to the cell.

CHEMICAL ACTION OF THE DRY CELL.— The action of the electrolyte on the carbon and zinc electrodes of the dry cell produces an electrical current flow when the cell is connected to a load. In the process of producing the electrical current, the chemical action eats away the zinc container (negative electrode). In the process of being discharged, it is common for the zinc container to be sufficiently eaten away that the electrolyte will leak from the cell. The electrolyte is corrosive and will destroy the internal parts of electrical or electronic equipment with which it comes in contact.

To prevent damage to electrical equipment from leaking electrolyte, dry cells should be replaced immediately after they have been discharged beyond their usable service life.

Battery-powered equipment should NEVER be placed in stowage until the dry cells have been removed.

SHELF LIFE OF THE DRY CELL.—A cell that is not being used (on the shelf) will gradually deteriorate because of slow internal chemical actions (local action) and changes in moisture content. However, this deterioration is usually very slow if cells are properly stored. High-grade cells of the larger sizes should have a shelf life of 1 year or more. Smaller size cells have a proportionately shorter shelf life, ranging down to a few months for the very small sizes. If unused cells are stored in a cool place, their shelf life will be greatly increased; therefore, to minimize deterioration, unused cells should be stored in refrigerated spaces (10° to 35° F) that are not dehumidified.

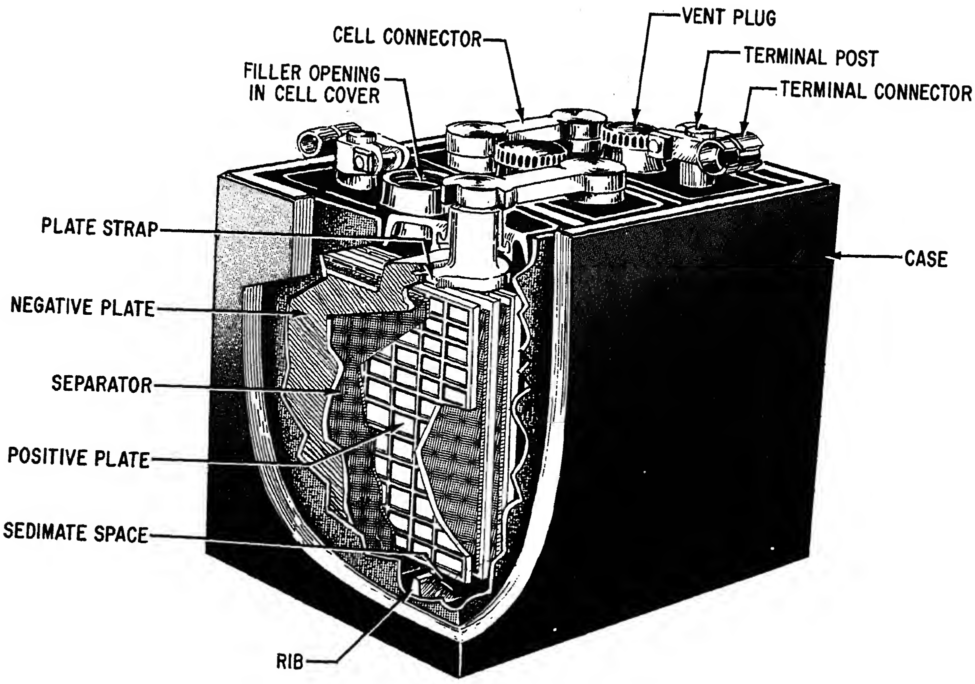
Secondary (Wet) Cells

Secondary cells function on the same basic chemical principles as primary cells. They differ mainly in that they may be recharged, whereas the primary cell is not normally r charged. Some of the materials of a prima cell are usually consumed in the process changing chemical energy to electrical energ In the secondary cell, the chemical reaction th produces the electricity does not consume th electrodes, but it does usually change the chemic composition of the electrodes. Discharged sec ondary cells may be restored (charged) to thei original state by forcing an electric curre from some other source through the cell i the direction opposite that of discharge.

There are many different types of secondar cells. Of these types, the lead-acid is the mo widely used.

LEAD-ACID BATTERY.—A lead-acid batter consists of a number of lead-acid cells connecte together, the number depending upon the voltag desired. Each cell produces approximately volts.

A lead-acid battery (fig. 7-2) consists of hard rubber, plastic, or bituminous materi compartment into which is placed the cell element consisting of the positive and negative lead plates The plates are insulated from each other b



236.3

Figure 7-2.—Lead-acid battery.

suitable separators (usually made of porous plastic, rubber, or glass) and submerged in a strong sulfuric acid solution (electrolyte).

Many batteries are assembled in a one-piece container with compartments provided for each cell. The cells are covered with the same material as the battery container. Openings are provided in the covers for the terminals and the vent plug.

The terminals of a lead-acid battery are normally distinguishable from one another by their physical size and by the markings of the manufacturer. The positive terminal, marked +, is slightly larger than the negative terminal, marked -. In addition, the terminals are sometimes color coded—red for the positive terminal and black for the negative terminal.

Vent plugs are of various designs to permit the escape of gases that form within the cells while preventing leakage or loss of the electrolyte.

It is important that the openings of the vent plugs do not become clogged with dried electrolyte and dirt. If this should happen, pressure sufficient to burst the battery case could build up inside the cells while they are being charged.

Lead-Acid Battery Operation.—The active materials in a charged lead-acid battery are lead peroxide (the positive plate) and sponge lead (the negative plate). The electrolyte is a mixture of sulfuric acid and water. The strength (acidity) of the electrolyte is measured in terms of its specific gravity. Specific gravity is the ratio of the weight of a given volume of electrolyte to an equal volume of pure water.

As the battery discharges, the acid in contact with the plates separates from the electrolyte and forms a chemical combination with the active material of the plates changing them to lead sulfate. Thus, as the discharge continues, lead sulfate forms on the plates, and more acid is taken from the electrolyte. The water content of the electrolyte becomes progressively higher; that is, the ratio of water to acid increases. As a result, the specific gravity of the electrolyte will gradually decrease during discharge.

If the discharged cell is properly connected to a direct-current charging source (the voltage of which is slightly higher than that of the cell), current will flow through the cell in the direction opposite that of discharge, and the cell is said to be charging. The effect of the current changes the lead sulfate on both the positive and negative plates back to the original active form of lead peroxide and sponge lead, respectively. At the same time the sulfate is restored to the electrolyte, thereby increasing the specific gravity of the electrolyte. When all the sulfate has been restored to the electrolyte, the specific gravity will be maximum. The cell is then fully charged and is ready to be discharged again.

During the battery charging operation quantities of hydrogen and oxygen gases are generated within the cell. If these gases are not vented, the cell container may burst; therefore, the gases must be vented to the atmosphere through the vent plugs.

A mixture of hydrogen and air can be dangerously explosive. No smoking, electric sparks, or open flames should be permitted near charging batteries.

If a lead-acid cell or battery is allowed to remain in a discharged condition for more than 24 hours, the lead sulfate on the plates hardens and it becomes increasingly difficult for the charging action to restore it back to the electrolyte. If allowed to remain in a discharged state for an excessive period of time, the cell cannot be restored to its original charged condition. Lead-acid cells should be maintained as near a fully charged condition as possible.

You should also remember that sulfuric acid added to a discharged lead-acid cell will NOT recharge the cell and, in fact, can damage the cell. Added acid only increases the specific gravity of the electrolyte; it does not convert the lead sulfate on the plates back into active material (sponge lead and lead peroxide) and, consequently, does not bring the cell back to a charged condition. A charging current must be passed through the cell to do this.

Only pure water should be added to a cell to maintain the electrolyte at the proper level.

Specific Gravity.—As the lead-acid cell discharges, the plates convert to lead sulfate, the sulfuric acid concentration in the electrolyte becomes weaker, and the specific gravity of the electrolyte approaches that of water (1.000).

A hydrometer (fig. 7-3) is used to measure the specific gravity of the electrolyte, thereby determining the charge/discharge state of a lead-acid cell. The electrolyte of the cell being checked is drawn up into the glass tube by means of the rubber bulb at the top. The specific gravity of the electrolyte is read from the calibrated scale, which lies axially along the body of the float.

There are several factors that may cause inaccuracies in hydrometer readings. The specific gravity of the electrolyte is affected by

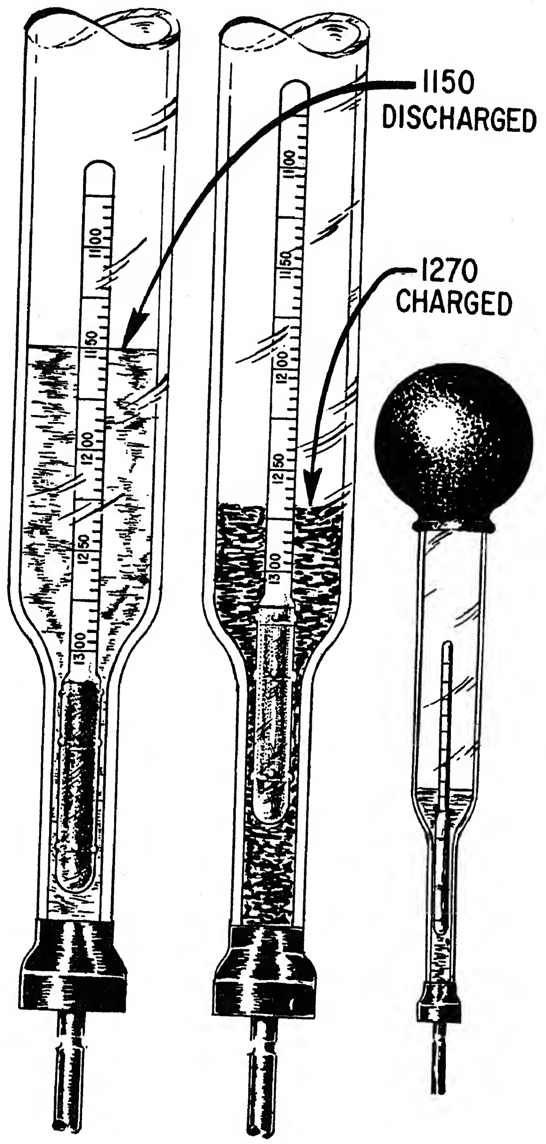


Figure 7-3. — Hydrometer. 236.39

its temperature. When heated, the electrolyte expands, becoming less dense and its specific gravity reading is lowered. Conversely, when cooled, the electrolyte contracts, becoming denser and its specific gravity reading is raised. Thus, effects of temperature will distort the readings.

When a reading is taken, the electrolyte in a cell should be at the normal level. If the level is below normal, sufficient fluid cannot be drawn into the tube to cause the float to rise. If t level is above normal, there is too much wat the electrolyte is weakened, and the readi will be too low.

A hydrometer reading is inaccurate if tak immediately after water has been added, becau the water tends to remain at the top of the ce When water is added, the battery should be charg for at least 1 hour to mix the water with th electrolyte before a hydrometer reading is take

CAUTION: Hydrometers should be flushe daily with freshwater to prevent inaccurate rea ings. Lead-acid battery hydrometers must NO be used for any other purpose.

Battery Capacity. — Batteries are rated their ampere-hour capacity at a definite ra of discharge. Most Navy portable lead-acid ba teries, except those used in aircraft, are rate at a 10-hour discharge rate. The capacity the battery, then, varies with how it is discharg in relation to its rated discharge rate. For ex ample: Suppose a battery is rated at 200 amper hours (will supply 20 amperes constantly to load for 10 hours). As shown in the table belo if it is discharged in less than 10 hours, it wi deliver less than its rated ampere-hour capacit

Discharge time	Percentage of ampere-hour capacity delivered
1 hour	55%
2 hours	65%
3 hours	75%
6 hours	90%
10 hours	100%

Types of Lead-Acid Battery Charges.—I general, battery charges are used to initiall activate a battery or to restore a battery to it charged state. The following types of charge may be given to a lead-acid battery, depende on the condition of the battery and PMS require ments:

1. Initial charge
2. Normal charge
3. Equalizing charge
4. Float charge
5. Emergency charge

When a new battery is shipped dry, th plates are in an uncharged condition. After th electrolyte has been added, the battery is give a long, low-rate, initial charge to convert th

plates into the charged condition. The charge is given in accordance with the manufacturer's instructions, which are shipped with each battery. If the manufacturer's instructions are not available, the charge should be made in accordance with detailed instructions in current directives.

A normal charge is a routine charge, given in accordance with the nameplate data during the ordinary cycle of operation, to restore the battery to its charged condition.

An equalizing charge is an extended normal charge, given periodically to ensure that all the sulfate is driven from the plates and to restore the electrolyte to its maximum specific gravity.

The floating charge is used to maintain a battery at its fully charged condition. In this type of charge, the battery is connected to a charging voltage that is slightly higher than the battery voltage, and the battery is charged constantly. The floating charge is usually used on batteries that are used as standby power sources for equipment such as dial telephones or gyrocompasses.

The emergency charge is used when a battery must be recharged in the shortest possible time. The charge starts at a much higher rate than is normally used and should be used only in an emergency because this type charge may be harmful to the battery.

Normally, the rate at which Navy lead-acid batteries are charged is given on the battery nameplate. If the available charging equipment does not have the desired charging rates, the nearest available rates should be used. However, the rate should never be so high that violent gassing occurs. NEVER ALLOW THE TEMPERATURE OF THE ELECTROLYTE IN ANY CELL TO RISE ABOVE 125° F.

NICKEL-CADMIUM BATTERIES. — Nickel-cadmium batteries are made in both wet and dry cell forms. Both forms are used in applications where lead-acid and conventional dry cell batteries are employed.

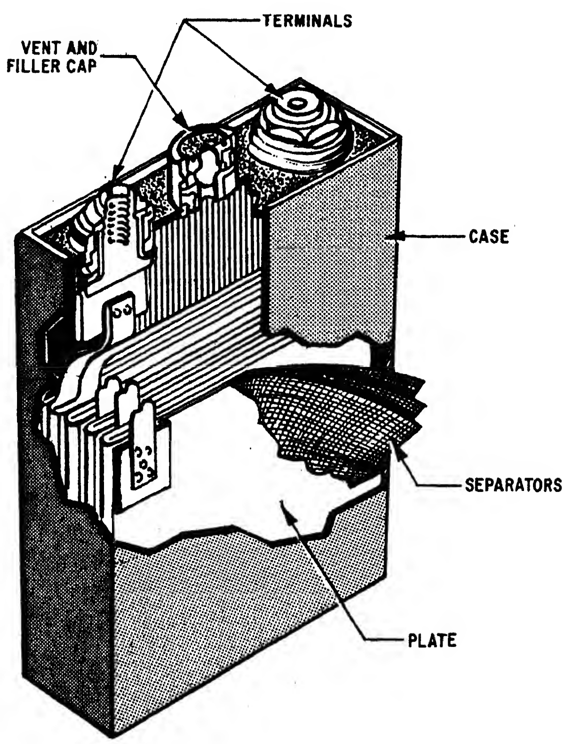
Nickel-cadmium cells are generally superior to lead-acid or dry cells:

1. In dry cell form they are longer lasting, capable of delivering more power per unit size, and may be recharged.
2. In wet cell form they are lighter, deliver more power per unit size and require less maintenance.

The main disadvantage of the nickel-cadmium battery is its high cost relative to conventional dry cells and the lead-acid battery.

Nickel-Cadmium Cell Construction. — The active materials of the nickel-cadmium cell (fig. 7-4) consist of nickel hydroxide on the positive plate and cadmium hydroxide on the negative plate. The electrolyte used in a nickel-cadmium battery is a caustic alkaline solution consisting of potassium hydroxide in distilled water. Chemically speaking, this is just about the exact opposite to the diluted sulfuric acid used in the lead-acid battery.

The electrolyte of the nickel-cadmium cell conducts current between the negative and positive plates and reacts with them to produce electrochemical changes without producing any significant change in its own chemical composition. For this reason, it is not possible to determine the charge state of a nickel-cadmium battery by checking the electrolyte with a hydrometer; neither can the charge be determined by a voltage test because of the inherent characteristic



236.40

Figure 7-4. — Nickel-cadmium cell.

that the voltage remains constant during 90 percent of the discharge cycle.

BATTERY MAINTENANCE

In general, the maintenance required to maintain any battery is dependent on its use. Some general information relating to the care, handling, and stowage of batteries is listed below. For detailed information relating to the maintenance and safety precautions for lead-acid and dry cell batteries, the manufacturer's technical manual, Naval Ships' Technical Manual, Chapter 313 (9622), or the PMS should be consulted. For detailed information relating to nickel-cadmium batteries, maintenance and safety precautions as well as other alkaline batteries, the technical manual furnished with the battery, Naval Aircraft Storage Batteries, NAVAIR 17-15BAD-1, or the PMS should be consulted.

Dry Cell Maintenance

The common carbon-zinc dry cell battery is popular largely because it is essentially maintenance free and very inexpensive. When used beyond serviceable life, these batteries are usually disposed of.

Alkaline versions of the dry cell are becoming increasingly popular in commercial as well as Navy equipment. The batteries are supplied as sealed units. They are usually kept on float charge by a battery charger built into the equipment in which they are installed. Maintenance is not usually required on these batteries and, as with the common dry cell, they are usually replaced when beyond their service life.

Because of chemical reactions within them, common dry cells deteriorate with age whether or not in use (25% to 50% energy is lost in 2 years.) Deterioration may be minimized by storing dry cells in a cool location that is not dehumidified.

Lead-Acid Battery Maintenance

Although the PMS specifies minimum preventive maintenance for lead-acid batteries, consideration should also be given to the application and conditions under which the battery is used.

ENGINE STARTING BATTERIES.— Because of the heavy demands on batteries used for starting propulsion engines, ship's boat engines, ship's service and emergency engine-generator sets, they are particularly liable to failure. Defects, which would hardly be noticeable in a battery used for less severe service, could result in total failure in an engine starting sequence. Because these batteries are sometimes subjected to the severities of salt spray and cold weather, as in the ship's boats, they should receive an increased amount of attention. You will find it exceedingly difficult to explain to your commanding officer why the ship's life boat engine will not turn over or why the ship's emergency generator will not start. These batteries therefore require frequent checking by competent personnel.

Batteries subjected to cold weather should be kept fully charged because:

1. Engines are harder to crank in cold weather.
2. The electrolyte, being part water, can freeze, causing damage to the battery and case. As a rule, the greater the percentage of acid in the electrolyte, the lower its freezing temperature. As an example, electrolyte with a specific gravity of 1.150 (equivalent to that found in a discharged battery) will freeze at -15° F, while electrolyte with a specific gravity of 1.300 will remain unfrozen at temperatures down to -95° F.

Grounds may be formed by dirt or acid on battery tops and sides. The ground path, through which current flows, can be established from the battery terminals through the acid and dirt along the top and sides to the ship's hull.

Battery grounds are undesirable because:

1. A ground in the vicinity of a battery may furnish the spark necessary to ignite an explosive gas mixture, if present.
2. A ground on the battery may cause a malfunction in the circuit to which the battery is connected.
3. Leakage current from the battery through the ground can cause dissipation of the energy in the battery.

In addition to forming grounds, dirt on battery tops and sides permits leakage current to flow directly from one terminal through the dirt and acid to the other terminal. This condition also dissipates the energy of the battery.

For the reasons stated above, batteries must be kept clean. All electrolyte, dirt, salt, corrosion, and foreign objects should be kept off battery tops and sides. Dirt and foreign material

on the top of a battery case increase the likelihood of their falling into the battery and contaminating it when the vent plugs are removed. In this respect, the presence of salt and saltwater merit special concern of maintenance personnel because chlorine gas is released when salt and sulfuric acid are combined.

Nickel-Cadmium Battery Care

The majority of nickel-cadmium batteries under the cognizance of the electrical division(s) are an integral part of electrical or electronic equipment which, as a rule, have built-in battery chargers that maintain the nickel-cadmium battery fully charged. These batteries are not usually subjected to severe usage but are used to supply power for a limited period to the equipment in case of normal power failure.

Maintenance for the units should be carried out as prescribed in PMS.

Dry Cell Safety Precautions

1. When equipment operated by dry batteries is to remain idle for more than 2 weeks, the batteries should be removed and either scrapped or stored.
2. Mercury-cell batteries may explode if improperly used. To prevent this occurrence, the following additional precautions must be followed:
   a. NEVER discharge a mercury-cell battery after the battery fails to operate the equipment, or after the voltage falls below 0.9 volts per cell.
   b. NEVER leave the battery switch "on" when the equipment is not in use, or after the battery fails to operate the equipment.
   c. NEVER impose a "dead short circuit" on a mercury cell, or allow it to become overheated. A temperature of approximately 400° F is sufficient to cause a mercury cell to explode.
   d. Mercury-cell batteries that have reached the end of their shelf-life while in storage should NEVER be issued to using activities.
   e. Discard exhausted mercury-cell batteries as soon as possible. Dead single and multicell mercury batteries with steel jackets should have holes punched in the jackets before being discarded to release any gas which might have formed.

Lead-Acid Battery Safety Precautions

1. Keep flames and sparks of all kinds away from the vicinity of lead-acid batteries.
2. Be sure to ventilate battery compartments, which have been sealed, BEFORE entering the compartment, turning on any lights, making or breaking any electrical connections, or doing any work in the compartment.
3. Be sure the ventilating apparatus of the battery compartment is running properly BEFORE starting a charge.
4. STOP the charge if ventilation is interrupted, except in an emergency, and DO NOT resume the charge until ventilation has been restored.
5. Charge a battery at the rates given on its nameplate.
6. When charging lead-acid batteries, NEVER allow the cell temperature to exceed 125° F.
7. Keep the temperature of the battery compartment below 95° F, if at all possible.
8. Make NO repairs to battery connections while current is flowing. NEVER connect or disconnect batteries on the charging line without first turning off the charging current.
9. When using tools around a battery, be careful NOT to short circuit the battery terminals.
10. When mixing electrolyte, always pour the acid slowly into the water; NEVER pour the water into the acid. Guard skin and eyes against splashes of acid with face shields, aprons, and rubber gloves.
11. DO NOT store pure sulfuric acid in places where temperatures below 50° F may be encountered.
12. Keep the electrolyte level above the tops of separators.
13. Add only pure distilled water to a battery.
14. DO NOT, except in an emergency, discharge the battery below the given low-voltage limit.
15. NEVER allow a battery to stand in a completely discharged condition for more than 24 hours.
16. DO NOT operate the battery when it reaches 125° F.
17. All sparks should be avoided during removal or replacement of batteries which are located in compartments that may contain gasoline fumes. Only tools with insulated handles should be used. For batteries that are used with one terminal grounded, the grounded terminal should be disconnected first when the battery is removed and connected last when the battery is being replaced.

18. NEVER allow saltwater to enter a battery cell because the interaction produces extremely toxic chlorine gas. Also, saltwater should NEVER be used to wash battery cases and jars.

19. Be sure all terminal connections are tight to preclude sparks due to loose connections.

If acid or electrolyte from a lead-acid battery comes into contact with the skin, the affected area should be washed as soon as possible with large quantities of freshwater, followed with an application of a salve such as petrolatum, boric acid, or zinc ointment. If none of these salves is available, clean lubricating oil will suffice. When washing the affected area, large amounts of water should be used because a small amount of water might do more harm than good in spreading the acid burn.

If acid splashes into the eyes, flush them immediately with large quantities of freshwater. Report to sickbay as QUICKLY as possible.

Acid spilled on clothing may be neutralized with dilute ammonia or a solution of baking soda and water.

Nickel-Cadmium Battery Safety Precautions

The electrolyte used in nickel-cadmium batteries is a strong caustic alkaline solution of potassium hydroxide as opposed to the sulfuric acid solution used in lead-acid batteries. Therefore, the antidotes used when parts of the body are affected with potassium hydroxide will differ from those used when parts of the body are affected by sulfuric acid.

If the alkaline electrolyte gets on the skin, wash the affected areas with large quantities of water, or take a shower immediately. Neutralize with a 3 percent solution of acetic acid and water, vinegar, or lemon juice, and wash with water.

If the alkaline electrolyte gets into the eyes, flush them immediately with large quantities of freshwater and wash the eyes with a weak solution of boric acid, or a weak solution of vinegar.

If alkaline electrolyte has been taken internally, drink large quantities of water and a weak solution of lemon juice, orange juice, or vinegar; follow with white of egg, olive oil, melted butter, starch water, or mineral oil.

In all cases seek medical attention IMMEDIATELY.

As with lead-acid batteries, the electrolyte used in the nickel-cadmium battery is corrosive. Serious burns will result if the electrolyte comes in contact with any part of the body. Use rubber gloves, rubber apron, and protective face shield when handling electrolyte.

Nickel-cadmium batteries should not be stored or serviced in the same areas with lead-acid batteries. DO NOT use the same tools, such as screwdrivers, wrenches, syringes, hydrometers and gloves for both battery types.

BATTERY CHARGING EQUIPMENT

The battery charging equipment employed by the Navy varies from the very small circuits that provide the very low charging current to float charge small nickel-cadmium batteries used in electronic devices to the large motor-generator and engine-driven generators used to charge submarine storage batteries.

Battery charging equipment must be capable of supplying voltages higher than that of the battery that is to be charged, and must be capable of supplying current commensurate with the battery's charging rate.

The most common types of shipboard battery charging equipment are the battery charging systems employed on ship's boats and the general purpose battery chargers.

The battery charging systems employed in the ship's boats are very similar to the systems found in automobiles except that in most cases they are designed to charge 24-volt batteries and most automobile batteries are rated at 12 volts. These systems consist of engine-driven generators or alternators which produce a d.c. voltage which is slightly higher than the battery voltage.

During the first several minutes of operation, the boat battery-charging system charges the battery to its full capacity to replace all the energy that was used to start the engine. After this initial period the charging system continues to charge the battery, supplying sufficient current to maintain it on a float charge. In addition to charging the battery, the charging system must supply power to all the electrical loads on the boat, while the engine is running.

The general purpose battery chargers employed aboard ships consist of the devices necessary to convert the ship's alternating current to a controlled direct current of the proper voltage to charge batteries. These battery chargers are usually capable of charging batteries rated at various voltages.

The general purpose battery chargers are used to charge batteries that are not installed in systems with integral battery chargers. In addition, they are used to provide supplemental charges to some batteries. For example, the batteries in the ship's boats are subjected to very heavy current drains during starting. The boat's engine may not always be run long enough to replace the energy used during starting and during long periods of inactivity; it is natural for the boat's batteries to lose energy. Therefore, it is very common for boat batteries to require charging from the ship's general purpose battery chargers.

SMALL BOAT ELECTRICAL SYSTEMS

The electrical systems found in small boats vary according to size and the intended purpose of the boat. In general, however, most boats possess electrical systems necessary for the operation of the boat's engine and navigational lights.

The electrical systems associated with the boat's engine consist of starting system, battery charging system, and those electrically operated instruments necessary to properly monitor the engine's operation. These systems operate in a manner identical to the same type systems found in automobiles, except that, as stated before, most small boat electrical systems operate at 24 VDC.

When built properly, each craft has navigational lights provided by the manufacturer. The number of lights and their locations are determined by the rules of the road governing the area where the boat is to be used principally (usually international rules of the road).

Electrical equipment aboard small craft is subjected to unusually severe conditions—humidity, salt spray, vibration, oil, and grease—and will require a great deal of attention. Navigation lights, because of their infrequent use, are often overlooked during routine inspections, thus creating embarrassing situations for electrical division personnel on more than one occasion. Naval Ships' Technical Manual, Chapter 583 (9820) contains more specific instructions relating to small craft electrical equipment, including navigation lights and safety precautions.

ELECTRICAL FORKLIFT TRUCKS

Electrical forklift trucks (fig. 7-5) are used primarily for handling and transporting heavy

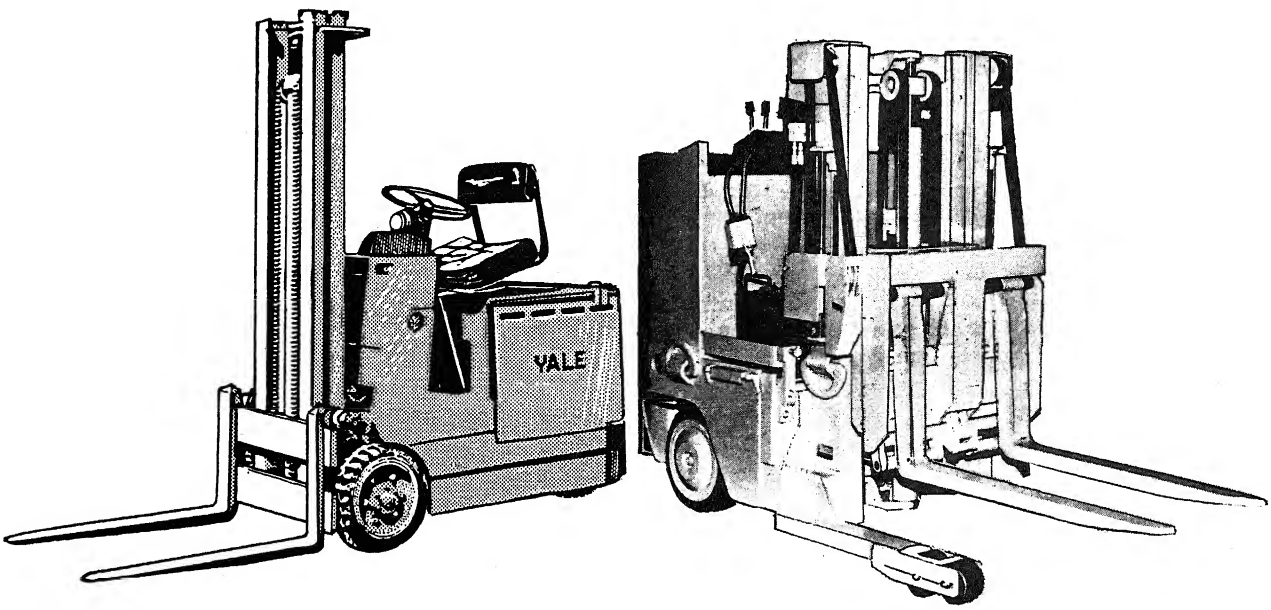


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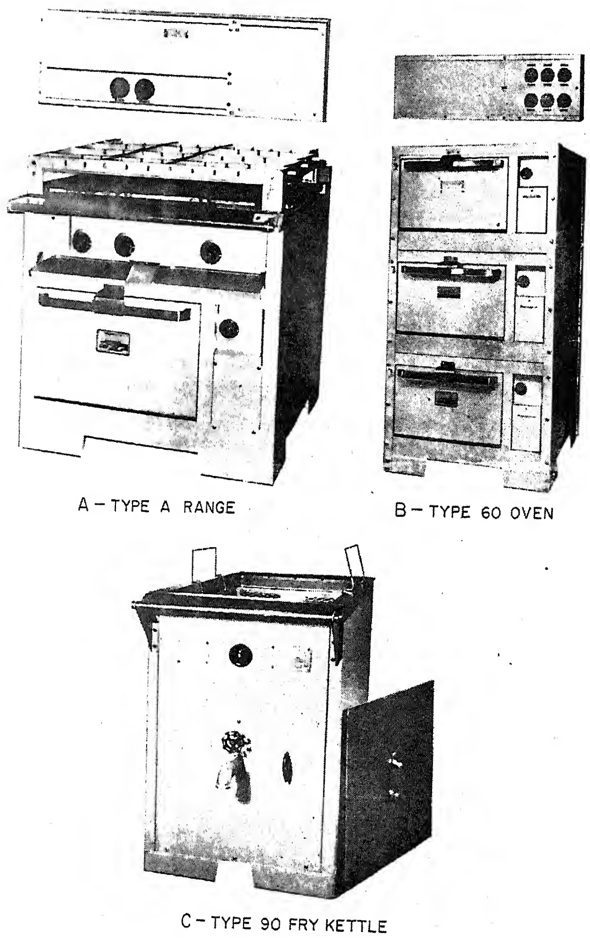
Figure 7-5.—Electric forklift truck.



48.8.11
Figure 7-6.—Electric galley equipment.

materials in confined areas where engine exhaust fumes cannot be tolerated. They are being used in ever increasing numbers aboard naval vessels of all types.

Large capacity lead-acid storage batteries (36 or 24 volt) are used to furnish power for the drive and lifting mechanisms. These batteries are usually of such design that they are easily replaceable. This feature makes it possible to remove an exhausted battery and to replace it with a fully charged battery from the ship's battery locker, permitting continuous use of the forklift.

The electrical components of the forklift include the battery, motors for the drive and lift mechanisms, and the control circuits requir for their operations. The control circuits for t drive and lift motors usually consist of sol state devices which provide smooth positi control through an infinite number of varyi speeds.

More detailed information regarding electri forklift trucks can be found in the manufacturer' technical manual for your particular equipme or in Electrician's Mate 3 & 2, NAVEDTR 10546.

ELECTRIC GALLEY EQUIPMENT

Electric galley equipment comprises the heav duty cooking and baking equipment installe aboard naval vessels and consists essentiall of ranges, griddles, deep fat fryers, roasting ovens, and baking ovens (fig. 7-6). This equipmen is supplemented by electric pantry equipment, which includes coffee urns, coffeemakers, griddles, hotplates, and toasters. The number and capacity of the units in a galley installation depends on the size and type of ship. Galley equipment is normally designed for operatio on 115-volt or 440-volt, 3-phase, 60-hertz, a.c. power.

RANGES

Electric galley ranges are provided in type A (36-inch), type B (20-inch), and type C (30-inch). The ranges consist of a range-top section and an oven section assembled as a single unit and a separate switchbox designed for overhead or bulkhead mounting. A type A range (fig. 7-6A) has three 6-kilowatt surface units and an oven section with two 3-kilowatt enclosed heating units.

OVENS

A type 60 roasting oven (fig. 7-6B) consists of separate ovens, each of which is thermally insulated and operated independently of the others. The roasting ovens are provided in either two or three sections mounted one above the other. Each oven has a separately mounted switchbox which contains the fuses, contactors, and two or three heat switches, one for each section.

The type number of the oven denotes the capacity in pounds of raw meat per section.

The type 12 and type 18 baking ovens are sectional type ovens with each section constituting a separate oven, thermally insulated and operated independently of the other sections. Each section of the type 12 or type 18 oven has a capacity of six standard five-loaf bread pans. The type 12 oven consists of two sections mounted one above the other. The type number denotes the total bread pan capacity of the oven.

DEEP FAT FRYERS

Electric deep fat fryers are normally provided in the type 23, type 45, and type 90 sizes. Each has enclosed electrical heating units rated at 5 kilowatts, 10 kilowatts, and 18 kilowatts, respectively. A type 90 deep fat fryer is shown in figure 7-6C.

The heating units are immersed directly in the fat to ensure maximum efficiency. The fryer is equipped with an adjustable automatic temperature control to maintain the fat at the desired temperature. The thermostat control, located on a panel at the front of the fryer, is provided with an OFF position and the adjustable temperature range of 250° to 400° F is displayed in gradations on the control knob. The thermostat operates contactors which, in turn, control the circuits to the heating units.

A compartment located inside the fryer contains the contactors, thermostat, heating unit terminals, line terminal block, fuses, and line switch. The compartment is equipped with a removable panel for easy access to the control devices.

Because of the fire hazards associated with deep fat fryers, they have been equipped with several safety devices. One of these safety devices consists of a circuit breaker located remotely from the deep fat fryer. The circuit breaker permits manual interruption of power to the deep fat fryer in case of fire or any other emergency. Also associated with the remote circuit breaker is a high limit thermostat located inside the deep fat fryer. If the main thermostat in the fryer fails, permitting the oil temperature to exceed 460° F, contacts in the high limit thermostat close and cause the remote circuit breaker to open automatically and interrupt power to the deep fat fryer.

ELECTRIC GALLEY EQUIPMENT MAINTENANCE

Some of the more common problems encountered with galley equipment are a result of the environment, cooking grease, oils, and high temperatures in which they operate.

One relatively common problem is corroded connections due to prolonged exposure to heat and cooking oils. Another common problem associated with galley equipment is grounds which are usually caused by carelessness on the part of those who are responsible for the cleanness of the equipment. Spilled water on electrical contacts and damaged electrical insulation are not uncommon occurrences.

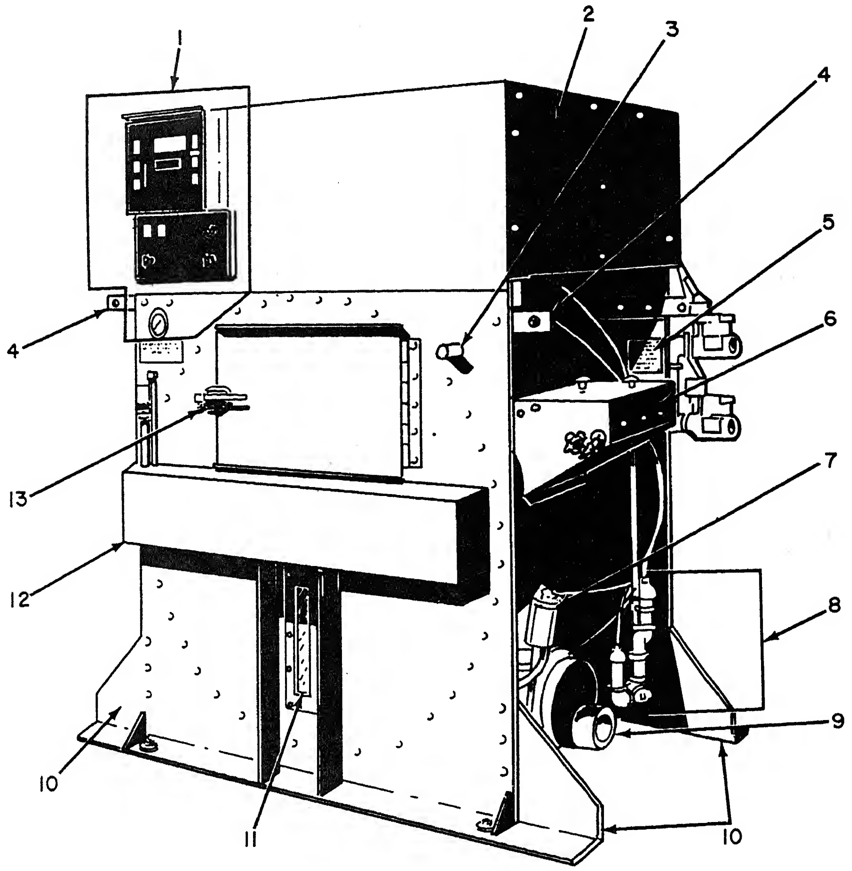
LAUNDRY EQUIPMENT

Laundry equipment aboard ship is comprised of washers, extractors, and dryers. They may be installed separately or in combinations. This equipment operates primarily on 3-phase, 440 VAC, 60-hertz power. The fully automatic washer-extractor with a card-o-matic programmer is a representative piece of equipment.

WASHER-EXTRACTOR

The cylinder of the washer-extractor (fig. 7-7) has a 100-pound dry weight capacity. A three-motor system drives the cylinder through its various wash/extract cycles by means of V-belts, speed reducers, and an air-operated clutch. Electric solenoids control the supply of air for operating the clutch, brake, drain and steam valves, and detergent dispenser. Water level is controlled by three pressure-operated level switches; the water temperature is controlled by three adjustable thermostats.

Though designed to operate automatically (formula mode), the washer-extractor can operate in the manual mode or in a combination of the two modes. The sequence and duration of the operations in the formula mode are controlled by the card-o-matic programmer (fig. 7-8) which also adds detergents and bleaches as programmed. In the manual mode, the machine operator controls the duration and sequence of the wash/extract cycle by positioning switches



Legend:

1. OPERATING CONTROLS
2. REMOVABLE SIDE PANEL
3. DOOR BUMPER
4. LIFTING BAR
5. DATA PLATE
6. SUPPLY HOPPER
7. DRAIN VALVE AIR CYLINDER
8. WATER LEVEL BELLS
9. DRAIN VALVE
10. BASE PLATE
11. SIGHT GLASS
12. FRONT PANEL
13. TUB DOOR LATCH

77.

Figure 7-7.—Front right view, Class 2258 Cascadex Washer-Extractor.

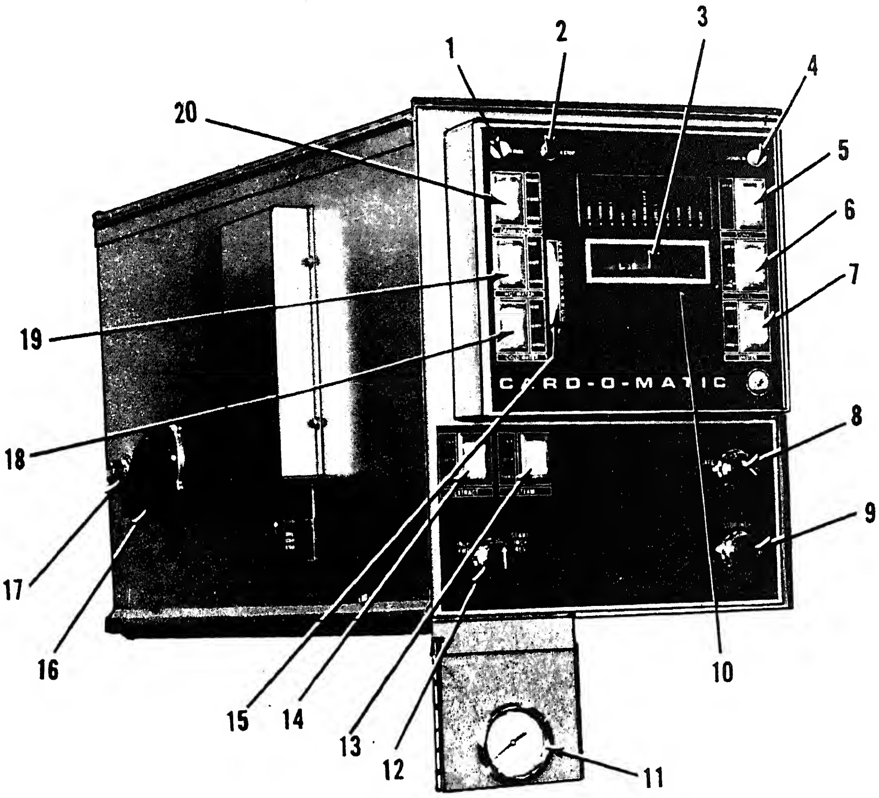
as desired. Detergents and bleaches are added as desired by manual operations.

Card-O-Matic Programmer

The card-o-matic programmer controls every operation of the washer-extractor when it is operated in the automatic or formula mode. The operator selects the proper formula card according to the type of washing to be done. The formula card, which is inserted into the card reader portion of the card-o-matic programm determines the wash time, water temperatı sequence of adding detergents, etc., during entire operation. Incorrect programming of formula card may cause the motor to s

LAUNDRY EQUIPMENT SAFETY AND MAINTENANCE

As a rule, present day laundry equipme complex in nature. This equipment is vit



1. RUN INDICATOR
2. STOP INDICATOR
3. FORMULA CARD WINDOW
4. SIGNAL INDICATOR
5. SIGNAL SWITCH
6. LEVEL SWITCH
7. MASTER SWITCH
8. SAFE ON SWITCH
9. STOP INCH PUSHBUTTON
10. INTERIOR LAMP (NOT SHOWN)
11. THERMOMETER
12. INCH START SWITCH
13. STEAM SWITCH
14. EXTRACT SWITCH
15. CARD ADVANCE WHEEL
16. DISCONNECT SWITCH
17. OVERLOAD RESET BUTTON
18. COLD WATER SWITCH
19. HOT WATER SWITCH
20. DRAIN VALVE SWITCH

77.330

Figure 7-8.—Location of operating controls and indicators.

the health and morale of the crew and should be maintained to provide the best possible service.

Most laundry equipment is equipped with a number of safety devices. If disabled, these safety devices can result, and have resulted, in shipboard fires, damage to equipment, damage to clothing, and in many cases personnel injuries. Special attention should be given these safety devices during preventive and corrective maintenance with extra special attention being given those devices designed to protect operator personnel.

FIN STABILIZER SYSTEMS

The fin stabilizer system is installed on FF's and FFG's to counteract the rolling motion of the vessel which results from wave motion and high speed maneuvers. The fin stabilizer systems installed on these ships are active, which means that some form of energy is supplied to move the fins. Though they are manufactured by different companies, we shall describe only the system designed by Sperry Rand since it is considered a representative system. This system

provides a high degree of ship stability and enhances ship performance.

GENERAL DESCRIPTION

The main components of the ship stabilizing system are two machinery units, a control console, and two motor controllers (fig. 7-9).

Each machinery unit consists of a fin and fin-actuating machinery and is designed to be welded to the ship's hull.

The two main hydraulic pump units are shock-mounted on the forward sides of the machinery units. Each pump unit consists of a variable delivery pump, a 50-hp electric-drive motor, and accessories.

All roll measuring devices and equipment for computing the required stabilizing actions are housed within the control console. Its control panel contains the control devices and indicators for monitoring the fin stabilizer system operation.

PRINCIPLES OF OPERATION

Wave action, which causes the ship to roll, can be counteracted by applying righting or stabilizing moments to the ship in the direction opposite that of the disturbing wave action. One method of producing the moments is by means of two underwater fins. The capacity of these fins to stabilize a ship depends on the speed of

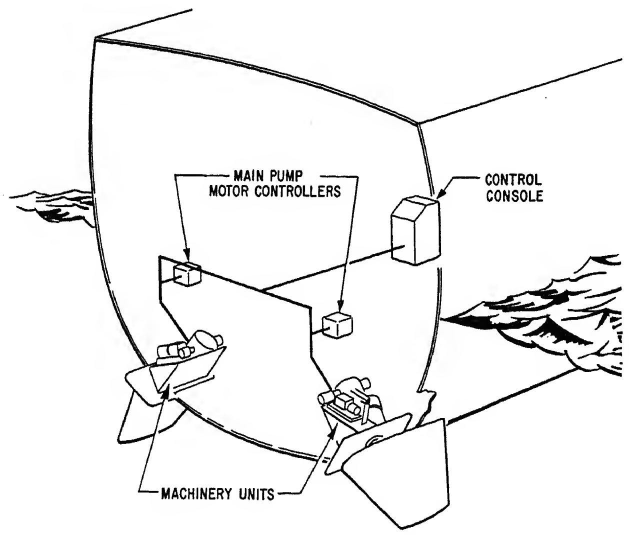


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Figure 7-9. — Typical fin stabilizer installation.

the vessel, size of the fins, and the manner i which they are controlled.

The fin stabilizer system, as shown in figu 7-10, consists of the control system, which con putes and orders the proper stabilizing momei and the machinery units, which develop t ordered stabilizing moment.

The roll sensors measure the rolling act caused by the disturbing wave action and tl supply data to develop the required stabiliz moments. The computer servo unit orders the servo to tilt the fin, creating a fin lift or fo resulting from the combination of the fin and ship's movement. A stabilizing mom (or antiroll torque) results from the actior this force on the lever arm between the and the ship's center of roll.

The equality in fin forces, or lifts, is assu by equality of the ordered lift signals f the computer servo unit and by measuren of the actual lift exerted by each fin. The ord lift signal and the actual lift signal are c pared in the positioning servos; any differ in them is used to change the fin angle actual lift is equal to ordered lift.

FIN STABILIZING SYSTEM MAINTENANCE

Fin stabilizer maintenance personnel strongly encouraged to refer to the man turer's technical manual throughout corre maintenance actions. Use of the technical m will greatly aid in troubleshooting and repa this equipment, as is true with all other equip

STEERING SYSTEMS

The steering system is considered one most vital auxiliaries since its operati necessary to maintain directional control vessel. Because of the vital role steering sy play, ships are usually provided with se different methods of direction control. method is made to operate as independen possible of the others. Several different supplies are provided to the steering sy and several means of controlling the st systems are provided on each ship.

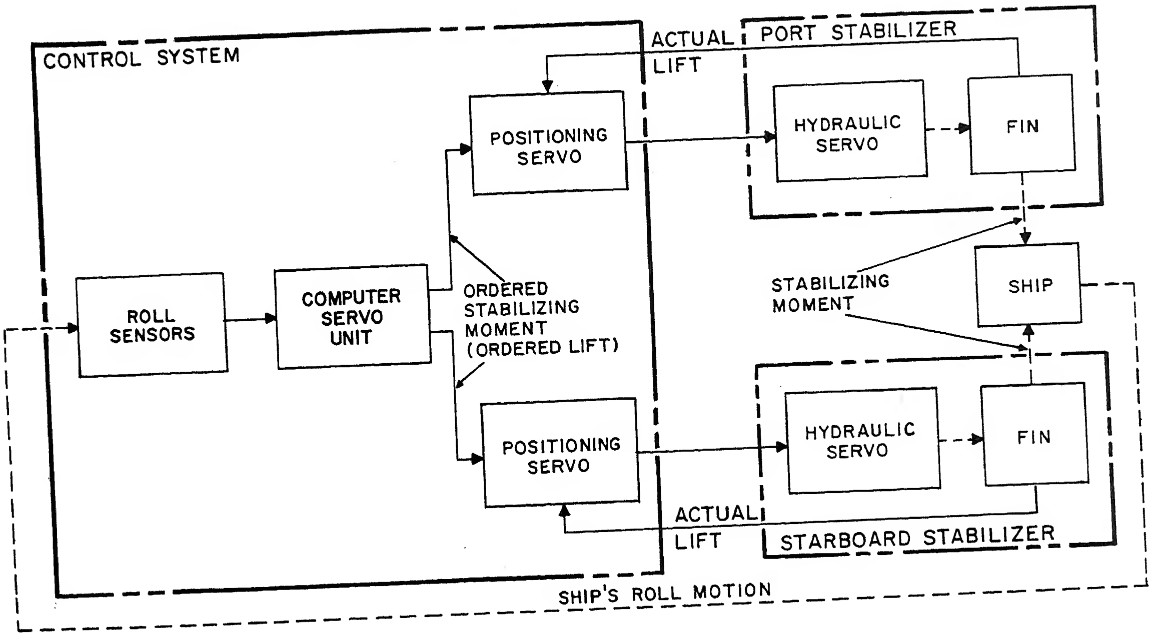

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Figure 7-10.— Block diagram of fin stabilizer system.

STEERING GEAR

The majority of steering gear installations in new construction naval vessels are of the electrohydraulic type. A typical electrohydraulic steering system is illustrated in figure 7-11. The electrohydraulic steering gear consists essentially of (1) a ram unit and (2) a power unit.

Ram Unit

The ram unit is mounted athwartship and consists of a single ram that operates in opposed cylinders. The ram is connected by links to the tillers of the twin rudders and is moved by the oil pressure built up in either of the cylinders, the oil from the opposite cylinder returning to the suction side of the pump.

A rack is attached to the ram and engages two gears (followup pinions), the rotation of which is transmitted to the respective differential control boxes through the followup shaft.

Power Unit

The power unit consists of two independent pumping systems, which include two motor-driven pumps, two transfer valves with operating gear, relief valves, two differential control boxes, and two "trick" wheels mounted on a bedplate, which also serves as the top of an oil reservoir. Steering power is derived from either pumping system acting alone. The power unit not in use serves as a standby unit in case of emergency.

The two pumps (port and starboard) are identical in size and design, and are of the variable delivery axial piston type. Each pump is driven by a 440-volt, 3-phase, 60-hertz induction motor through a flexible coupling.

The pumps of the power unit are connected to the ram cylinders by a high-pressure piping system. The two transfer valves are interposed in this piping, and their positions determine which pump is connected to the cylinders in the ram unit. A hand lever and mechanical leakage (not shown) is connected to the two transfer valves in such a way that, by positioning the lever, both of the transfer valves are operated simultaneously. The hand lever is usually located between the trick wheels and it has three positive detent positions. The detented positions are marked P, N, and S which denote port pump connected to the ram, neutral (neither pump connected to the ram) and starboard pump connected to the ram, respectively. Usually, the

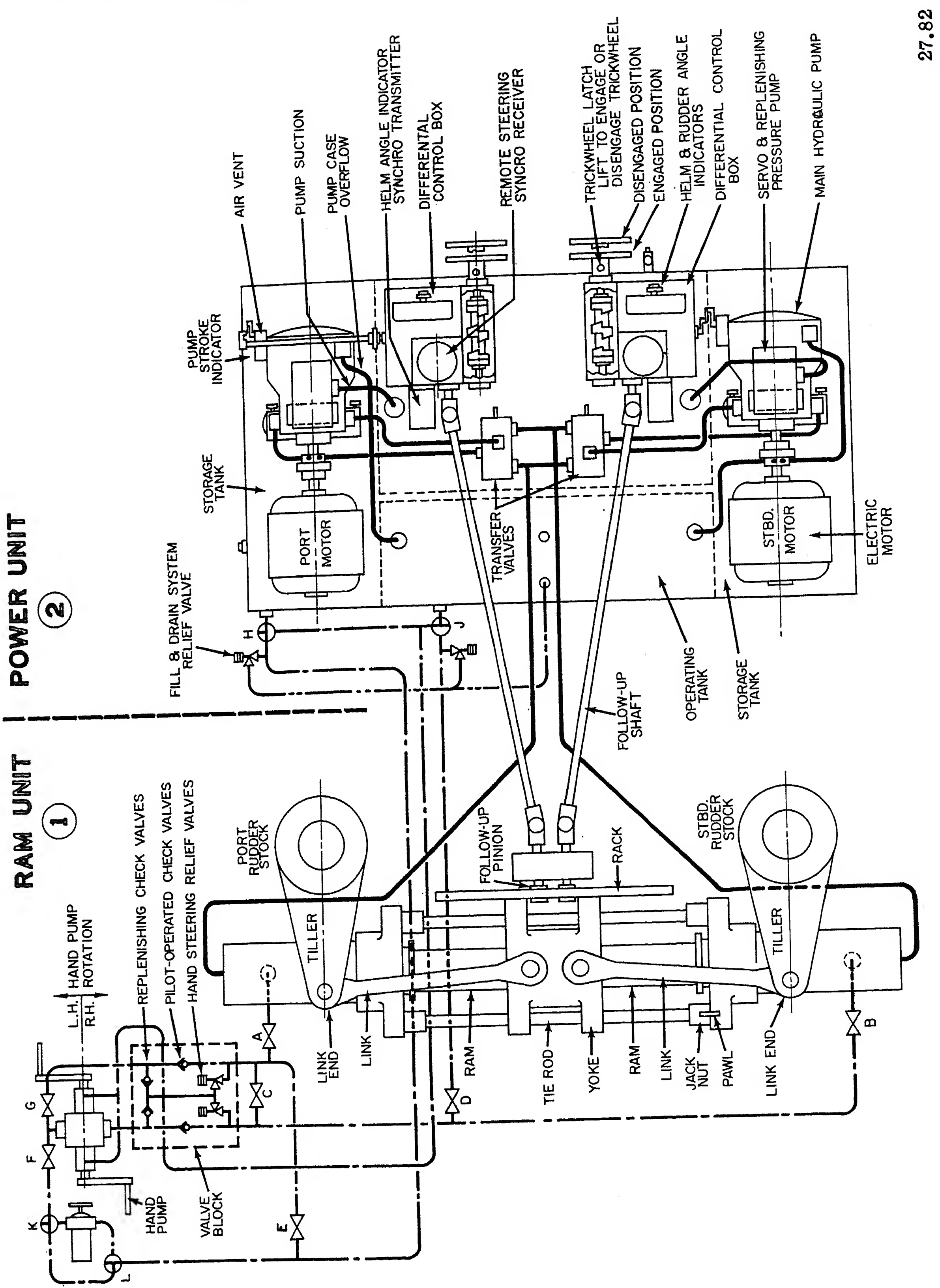

Figure 7-11.—Electrohydraulic steering gear.

hand lever is also connected to remote motor-starting switches, permitting the operator to connect the selected pump to the ram and start the pump drive motor in one quick operation. This arrangement is most beneficial in the event of failure of the operating unit because it permits steering power to be shifted to the standby unit with one swift motion.

The mechanical differential control box serves to correlate the mechanical signals from the followup shaft (which represents the rudder position) and the trick wheel, or the remote steering system (which represents the desired rudder position). If the desired and actual mechanical signals are the same, the mechanical output from the differential control box will be zero. If the two signals are not in correspondence, the differential control box will produce a mechanical output. The mechanical output is used to control the pump and, therefore, the

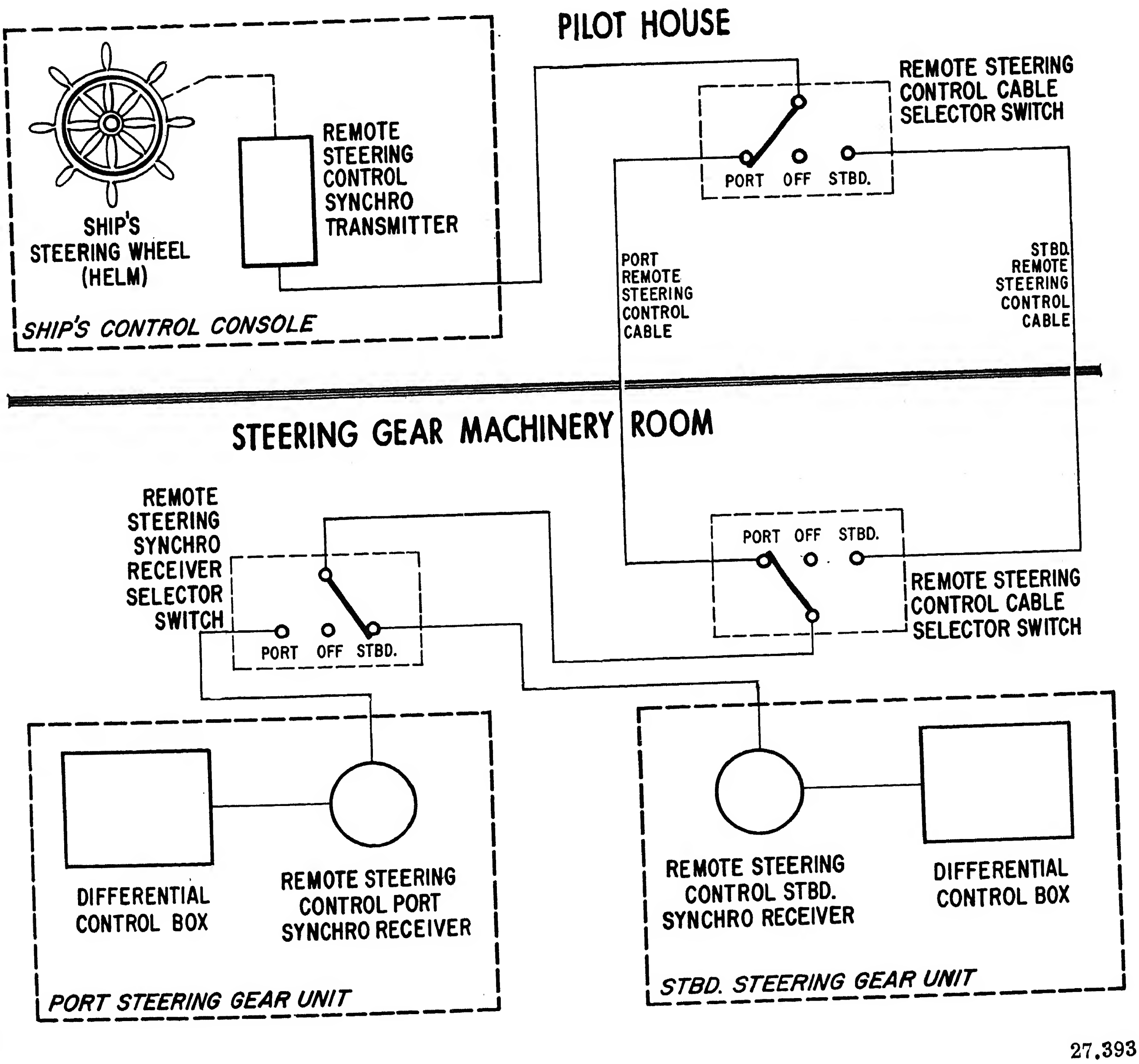

Figure 7-12.—Remote steering control system.

direction of hydraulic oil flow and pressure to the rams. Oil pressure from the pump causes the ram to move, which repositions the followup shaft, and movement continues in the desired direction until the differential control box output equals zero.

REMOTE STEERING CONTROL SYSTEM

The remote steering control system provides control from the pilothouse for normal steering. Refer to figure 7-12. Movement of the pilothouse steering wheel rotates a synchro transmitter which is electrically connected to either of the synchro receivers located in the electro-hydraulic steering control mechanisms. Two sets of cables are installed between the transmitter and receiver synchros. To provide maximum protection from battle damage, one set is installed on the port side of the ship, and the other is installed on the starboard side of the ship. A selector switch is installed in the pil house and in the steering gear room to per selection of the control signal on either the p or the starboard cable. These two switc must be set to select the same cable dur operation. A third selector switch, instal in the steering gear room routes the stee control signal to either the port or starbo synchro receivers located in the steering g unit to be used. This switch should be in OFF position when the trick wheel is to used. As shown in figure 7-12, the switc are aligned so that the port cable and starboard synchro receiver are selected. actual operation, any combination may be u

During remote control operation, the synch transmitter in the pilothouse drives the sele synchro receiver. The receiver synchro mec ically drives the input shaft of the differe unit which controls the pump unit. The t wheel may be used to provide a mechar input to the differential control unit when i engaged. The trick wheel and synchro rece inputs are mechanically the same.

CHAPTER 8

ALARM AND WARNING SYSTEMS

Although they often constitute little more than a power source, a switch and a signaling device, the alarm and warning systems of the various Interior Communications systems are extremely vital to any ship's operation. Although simple in design and principles of operation, the importance of the alarm and warning systems cannot be overemphasized. They warn watchstanders of conditions that are dangerous to personnel or of conditions that could result in equipment damage if the equipment is allowed to operate under those conditions for an extended period.

Over the years an attitude of indifference towards the alarm and warning systems has prevailed to the extent that, on any given naval unit, a number of these systems could be inoperable with little or no effort being expended to correct the problems. As a rule, the alarm and warning systems in the engineering spaces are the most seriously degraded. This may be attributed to three major reasons:

1. These systems are subjected to extreme humidity and temperatures.

2. The likelihood of physical damage to the systems is much greater because heavy equipment is rigged into and out of the spaces.

3. The maintenance and testing of the alarm and warning systems usually require the efforts of individuals from at least two separate divisions.

Effective coordination of the efforts of two or three divisions is difficult. Personnel do not arrive on station at the appointed time, therefore, man-hours are lost and disinterest grows. Those people who have no time to waste hesitate to assign their men to these details. The situation can continue to deteriorate to the point that efforts cease.

As an officer in the Engineering Department you should ensure that each of the alarm and warning systems functions entirely as it was designed to do, and that every effort is made to coordinate the testing of all the components within the alarm system by simulating the conditions which the alarm is intended to detect.

A listing of some of the alarm and warning systems with their circuit designations and classifications is contained in table 8-1. The principal components of alarm and warning systems are switches or contact makers, relays, thermostats, and audible and visual signals.

SWITCHES

Switches used with alarm and warning systems include manual lever-operated switches, pressure and thermostatic switches, mechanical switches, and water switches. Relays are used to open and close circuits which may operate indicating lights, annuciators and/or audible signals.

LEVER-OPERATED SWITCH

Many types of lever-operated switches (fig. 8-1) are used in Navy alarm and warning systems to complete electrical circuits to various types of audible and visual alarm signals. Two types of standard switches are available. One type has a spring return mechanism, and the other type has a positive detent mechanism. The type of switch used depends on the circuit in which it is installed.

Special switches are used where the standard switches cannot be used. For example, the diving alarm switch on the submarine bridge must be pressure proof. For submarine service, a distinctive shape is used for the operating lever knob or heads of alarm switches in conning

Table 8-1.—Alarm and Warning Systems

Circuit	System	Importance	Readiness Class
BZ	Brig cell door alarm and lock operating	NV	4
BW	Catapult Bridle Arresterman safety Ind.	NV	1
CX	Bacteriological Lab. & Pharmacy Comb. Refer Failure	NV	1
DL	Secure communications space door position alarm	NV	1
DW	Wrong direction alarm	V	2
EA	Reactor compartment or fireroom emergency alarm	NV	1
IEC	Lubricating oil low pressure alarm-propulsion machinery	SV	2
2EC	Lubricating oil low pressure alarm-auxiliary machinery	SV	1
1ED	Generator high temperature alarm	SV	1
2ED	Oxygen-nitrogen generator plant low temperature alarm	NV	1
EF	Generator bearing high temperature alarm	SV	1
EG	Propeller pitch control, hydraulic oil system low pressure alarm	SV	2
EH	Gas turbine exhaust high temperature alarm	SV	1 (aux. machinery 2 (prop. machiner
EJ	Feed pressure alarm	SV	1
1EK	Pneumatic control air pressure alarm	NV	2
3EK	Catapult steam cutoff and alarm	NV	2
XEL	Radar cooling lines temperature and flow alarm	NV	1
EP	Gas turbine lubricating oil high temperature alarm	SV	1 (aux. machinery 2 (prop. machiner
1EQ	Desuperheater high temperature alarm	SV	1
2EQ	Catapult steam trough high temperature alarm	SV	2

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Table 8-1.—Alarm and Warning Systems—continued

Circuit	System	Importance	Readiness Class
3ES	Reactor fill alarm	V	1
ET	Boiler temperature alarm	NV	1
EV	Toxic vapor detector alarm	SV	1
1EW	Propulsion engines circulating water high temperature	SV	1
2EW	Auxiliary machinery circulating water high temperature	SV	1
EZ	Condenser vacuum alarm	SV	2
F	High temperature alarm	SV	1
4F	Combustion gas and smoke detector	SV	1
9F	High temperature alarm system-ASROC launcher	SV	1
11F	FBM storage area temperature and humidity alarm	SV	1
12F	Gyro ovens temperature and power failure alarm	SV	1
FD	Flooding alarm	NV	1
FH	Sprinkling alarm	SV	1
FL	Flight Deck Landing Area Status Light Signal system	NV	2
FR	Carbon dioxide release alarm	NV	1
FS	Flight Deck Readylight Signal system	NV	2
FZ	Security alarm (CLASSIFIED)	V	1
4FZ	Torpedeo alarm (CLASSIFIED)	V	1
HF	Air flow indicator and alarm	SV	1
LB	Steering Emergency Signal system	NV	2
LS	Submersible steering gear alarm	SV	2

27.352.1

Table 8-1.—Alarm and Warning Systems—continued

Circuit	System	Importance	Readiness Class
MG	Gas turbine overspeed alarm	SV	1 (aux. machinery) 2 (prop. machinery)
NE	Nuclear facilities air particle detector alarm	NV	1
NH	Navigation Horn Operating System	NV	2
QA	Air lock warning	NV	1
QD	Air filter and flame arrester pressure differential alarm, or gasoline compartment exhaust blower alarm	V	1
QX	Oxygen-nitrogen plant ventilation exhaust alarm	SV	1
RA	Turret emergency alarm	NV	1
RD	Safety observer warning	NV	2
RW	Rocket and torpedo warning	SV	3
4SN	Scavenging air blower high temperature alarm	V	2
SP	Shaft position alarm	NV	2
TD	Liquid level alarm	NV	1
1TD	Boiler water level alarm	NV	1
2TD	Deaerating feed tank water level alarm	NV	1
5TD	Reactor compartment bilge tank alarm	SV	1
6TD	Primary shield tank, expansion tank level alarm	NV	1
7TD	Reactor plant fresh water cooling expansion tank level alarm	NV	1
8TD	Reactor secondary shield tank level alarm	NV	1
9TD	Lubricating oil sump tank liquid level alarm	SV	1
11TD	Induction air sump alarm	SV	1
12TD	Diesel oil sea water compensating system tank liquid level alarm	SV	1
14TD	Auxiliary fresh water tank low level alarm	NV	1

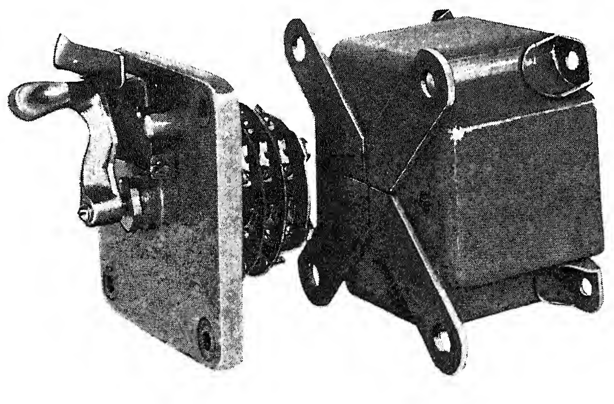
27.3

Table 8-1.—Alarm and Warning Systems—continued

Circuit	System	Importance	Readiness Class
16TD	Pure water storage tank low level alarm	SV	1
17TD	Reserve feed tank alarm	NV	1
18TD	Effluent tanks and contaminated laundry tank high level alarm	V	1
19TD	Sea water expansion tank low level alarm	SV	1
20TD	Gasoline drain tank high level alarm	SV	1
21TD	Moisture separater drain cooler high level alarm	NV	1
24TD	Reactor plant on board discharge tank level alarm	V	1
25TD	Crossover drains high level alarm	SV	1
29TD	Sonar dome fill tank low level alarm	SV	1
30TD	JP-5 fuel drain tank high level alarm	SV	2
TW	Train Warning system	NV	1
W	Whistle Operating System	NV	2

Legend:
V—Vital SV—Semivital NV—Nonvital.
1—Continuously energized-supply switch color code yellow.
2—Energized when preparing to get underway, while underway, and until the ship is secured-supply switch color code black.
3—Energized during condition watches -supply switch color code red.
4—Energized only when required-supply switch color code white.
All electronic type alarm systems formerly designated as circuits CA, FC, FW, G, GD, GJ, GN, and GP are now classified as a portion of the respective announcing system with which they are associated.

27.352.1



140.4

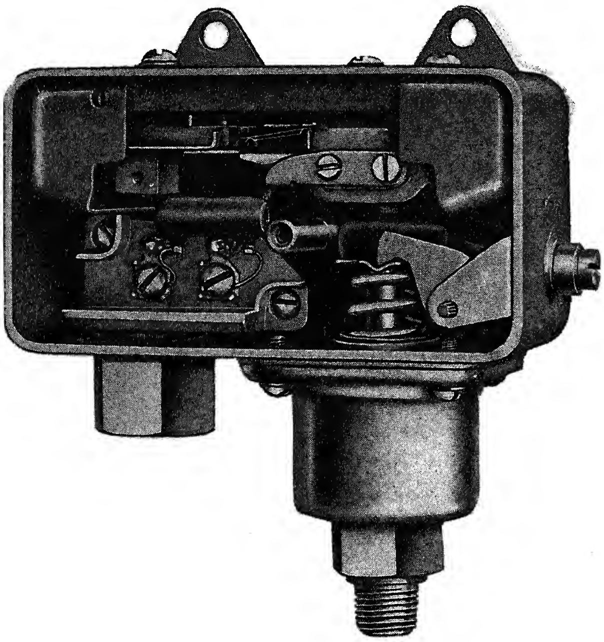
Figure 8-1.—Lever-operated switch (manual contact maker).

tower and control room (where illumination is low) to avoid confusion in operating the proper switch. A square-shaped knob is used for the diving alarm switch, a star-shaped head for the collision alarm switch, and a standard round head for general alarm.

Lever-operated switches are used in such systems as the fireroom emergency signal, general alarm, chemical-attack alarm, steering emergency signal, whistle operation, life buoy release, and flight-crash signal.

PRESSURE SWITCH

Pressure-operated switches (fig. 8-2) contain either a bellows or a diaphragm that works against an adjustable spring. The spring causes the contacts to close or open automatically when



77.119(140)
Figure 8-2.— Pressure switch type IC/L.

the operating pressure falls below or exceeds a specified value. These switches are available to sense pressure changes in ranges of 0-15, 15-20, 50-100 pounds, etc. Special switches are available which sense very high pressure or vacuums. The exact pressure at which the contacts close or open is adjustable, as long as the desired setting is within the range of the switch.

Pressure-operated switches are used with the lubricating oil low-pressure alarm system, pneumatic control air pressure alarm system, and booster-feed pressure alarm system, as well as others. Pressure-operated switches are also used to control electrical circuits; for example, to start an electrically driven emergency lube oil pump when the pressure from the main pump falls below a specified value.

THERMOSTATIC SWITCHES

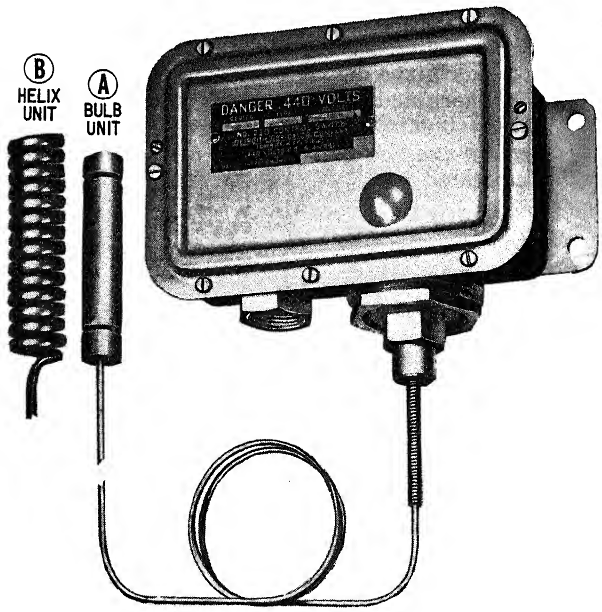
The Navy uses two basic types of thermostatic switches for alarm circuits: type IC/N and mercury.

Thermostatic Switch Type IC/N

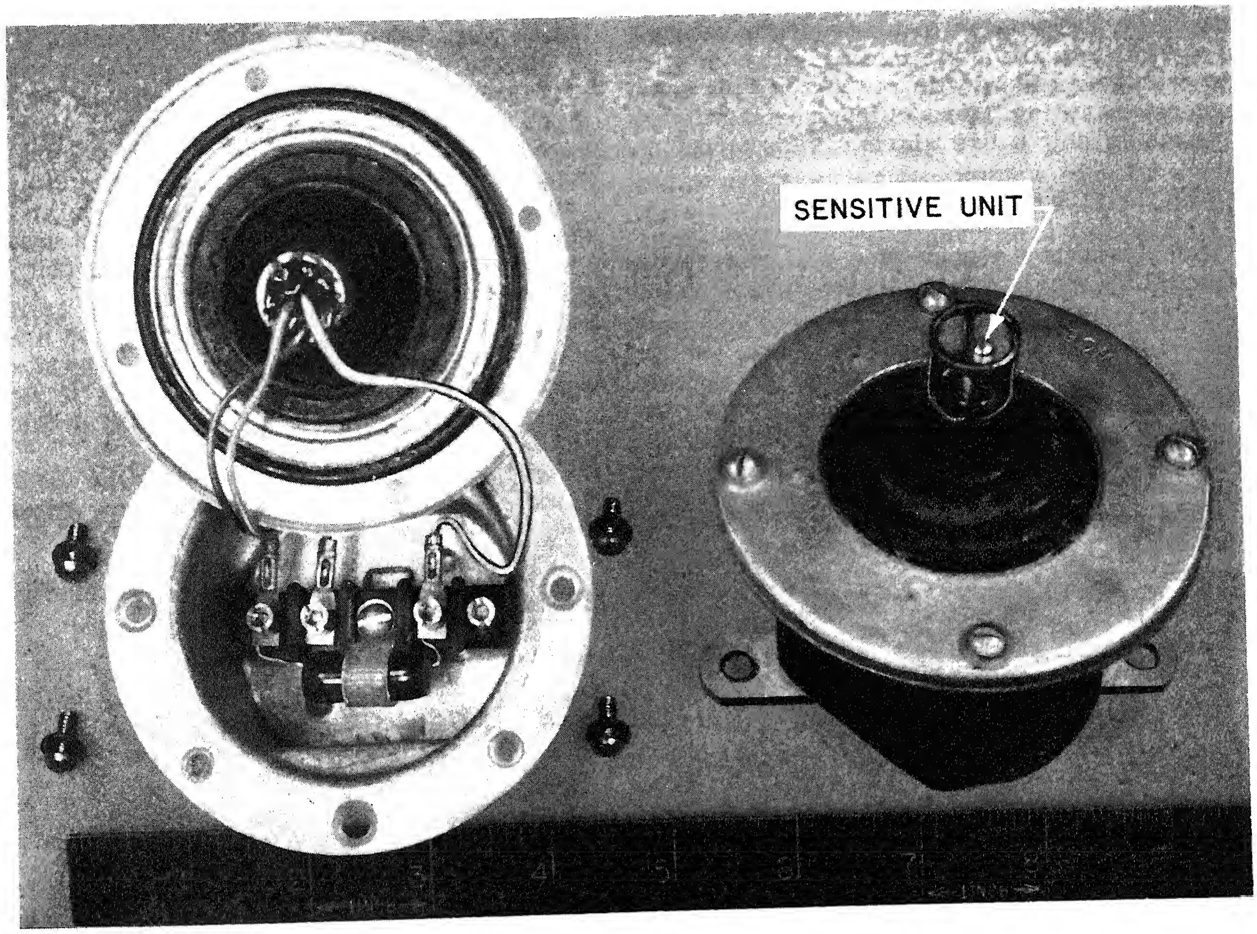
The type IC/N thermostatic or temperature-operated switches (fig. 8-3) are constructed similarly to the previously discussed pressure switches. Each switch contains a bellows which works against an adjustable spring. The spring causes the contacts to close or open automatically when the operating temperature exceeds or falls below a specified value. The motion of the bellows is produced by a sealed-in liquid that expands with rising temperature. The sensitive element containing this liquid may be an integral part of the switch or it may be located in a remote space and connected to the switch by a capillary tube.

The thermostatic switch is available to sense a wide range of temperatures; each switch is adjustable to a specific temperature within its range. The thermostatic switch physically resembles the pressure switch except that a sensitive element or capillary tube is connected where the pressure source would be connected to the pressure switch.

The IC/N temperature-operated switches are used with the circulating-water high-temperature



77.1?
Figure 8-3.—Thermostatic-operated switch, Ty[p]
IC/N.



27.308

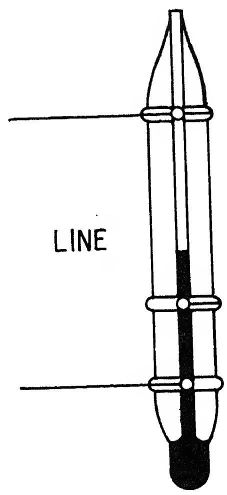
Figure 8-4.—Mercury thermostat.

alarm system, cruising-turbine exhaust alarm system, and generator-air high-temperature alarm system, as well as others.

Mercury Thermostatic Switch

The sensitive unit of the mercury thermostatic switch (fig. 8-4 and 8-5) is similar in construction to an ordinary mercury thermometer, except that three metal electrodes are inserted into the glass enclosure. The electrodes complete contact with the mercury column as the height of the mercury increases in the glass tube. An increase in temperature results in the mercury's shorting out the upper and lower contacts which completes the electrical circuit; the middle contact is used in conjunction with the supervisory circuit which will be discussed later in this chapter.

The thermostats are designed to close their contacts at temperatures of 105°, 125°, or 150°F.



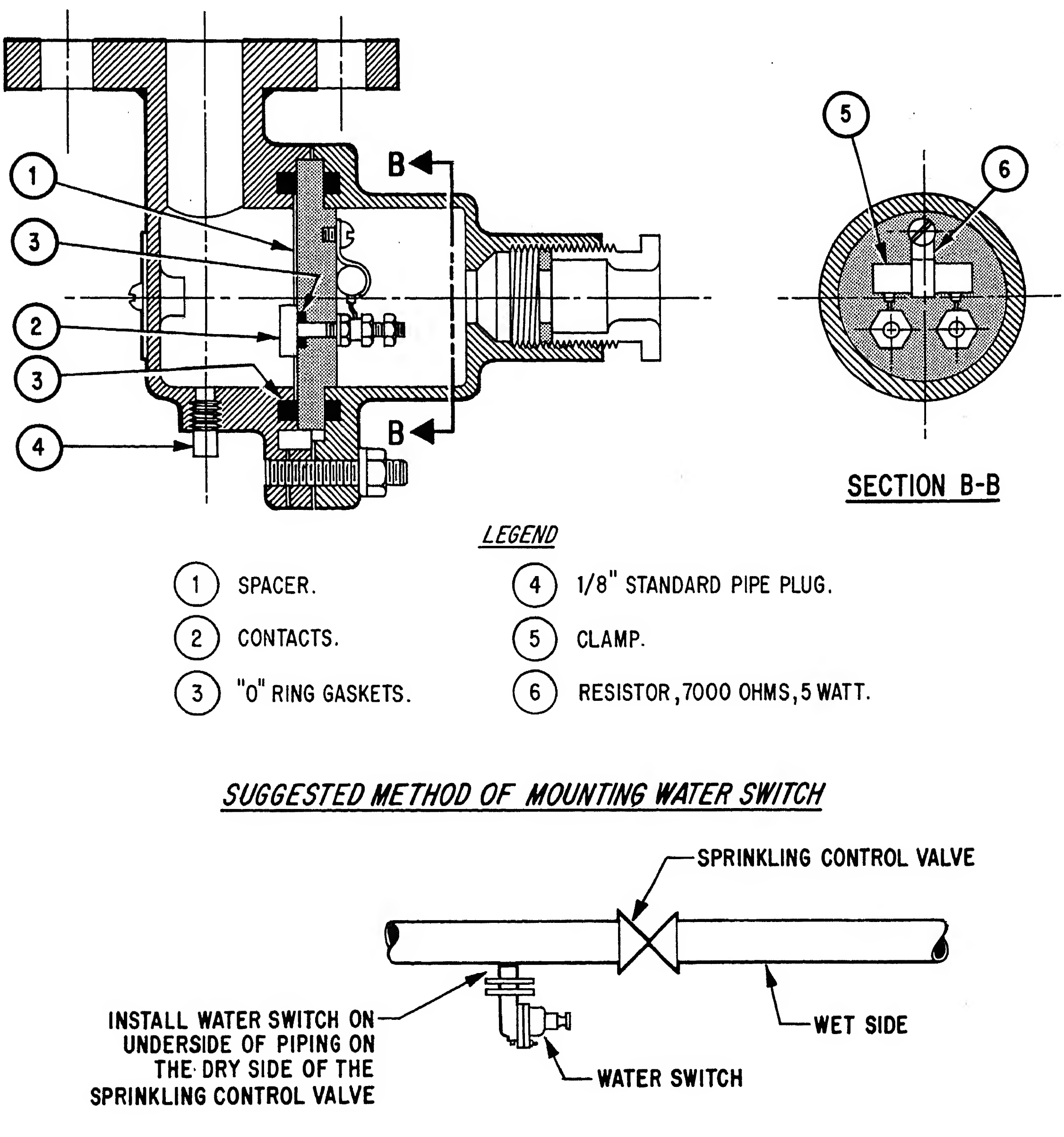
27.309

Figure 8-5.—Mercury thermostat sensitive unit.

Except for differences in temperature ratings, the thermostats are similar. A defective thermostat must be replaced with one that has the same temperature rating. Mercury thermostat switches are used in ship's fire alarm system circuit F.

WATER SWITCH

Water switches consist of a pair of contacts mounted on an insulated base within a cast fitting (fig. 8-6). The switch is mounted in the magazine flooding system with a sprinkling control valve installed between the switch and the fire main. When the sprinkling control valve is opened, salt water floods the switch casting and shorts out the contacts, thereby permitting a current flow of sufficient value to operate the alarm. The resistor in figure 8-6 is used in conjunction with the supervisory circuit and will be discussed later in this chapter.



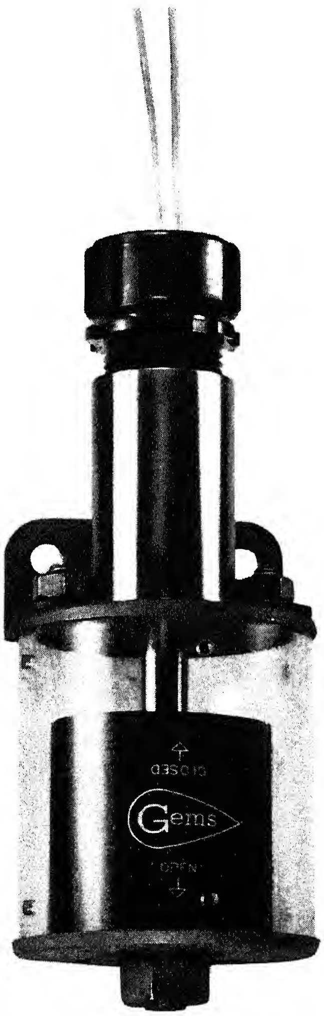
140.

Figure 8-6.—Water switch.

LIQUID-LEVEL FLOAT SWITCH

The liquid-level float switch (fig. 8-7) is used in tank and bilge level alarm circuits. The switch assembly consists of a center column with a magnetically operated reed switch encapsulated inside it. A float, containing a magnet, surrounds the center column and is free to move up and down the column. The movement of the float with its magnet causes the contacts of the reed switch to open or close. By mounting the switch assembly at a predetermined level in a tank or bilge, it can be made to give above or below normal liquid level indications.

The liquid level float switch is used in the flooding alarm circuit FD, as well as others.



140.63X
Figure 8-7.—Float switch.

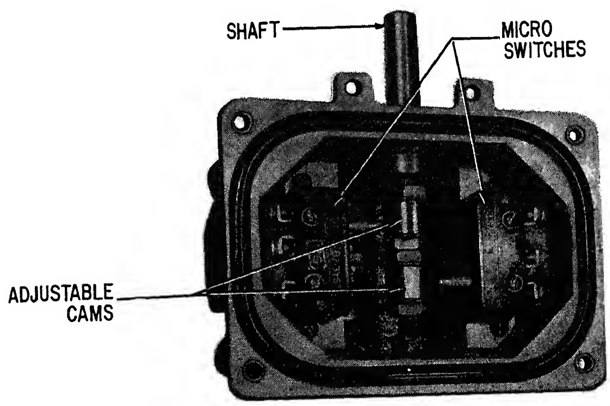
MECHANICAL SWITCH

Mechanical switches are employed to indicate the position of a component or to sound an alarm if the component is not in the proper position. These switches usually contain microswitches which are actuated by either a cam or a push-operated plunger. The push-action plunger mechanism utilizes a straight line movement of the shaft to operate a microswitch.

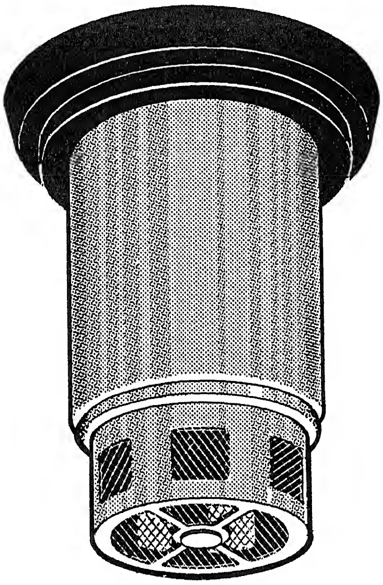
The cam-action switch consists of two micro-switches operated by two adjustable cams mounted on the rotor shaft (fig. 8-8.) The cam-action mechanism utilizes a rotary motion of the shaft to move cams, which in turn operate micro-switches. The points of operation of the micro-switches are varied by adjustment of the angular positions of the cams with respect to the shaft on which they are mounted. Mechanical switches are used in the secure communications space door position alarm (circuit DL); wrong direction alarm (circuit DW); airlock warning (circuit QA); as well as in other circuits.

COMBUSTION GAS AND SMOKE DETECTOR

The combustion gas and smoke detector (fig. 8-9) is an electronic switch. The presence of smoke or combustion gases causes the internal resistance of the detector to decrease drastically, thereby allowing it to conduct a larger current in much the same way as the closing of the mechanical contacts of an ordinary switch. The detector contains small quantities of radium and, therefore, should be handled and disposed



140.6
Figure 8-8.—Cam-action mechanical switch.



27.310
Figure 8-9.—Combustion gas and smoke detector head.

of in accordance with current directives for radioactive material. The combustion gas and smoke detector is used in the combustion gas and smoke detection system IC circuit 4F.

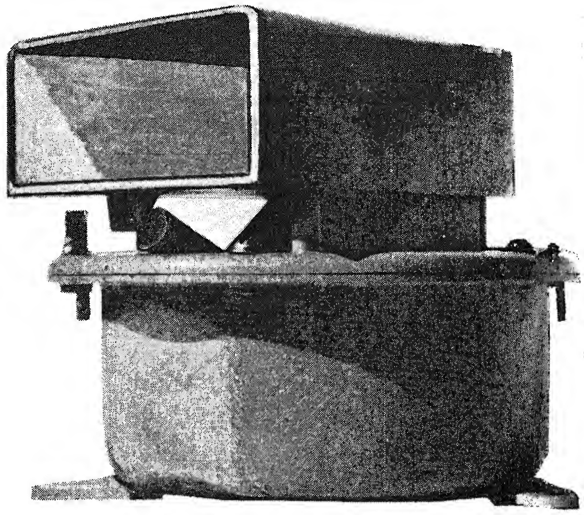
AUDIBLE SIGNALS

There are many types of audible signals in use aboard Navy ships. The principal types of audible signals are bells, buzzers, horns, and sirens. Electronic signals are used for some applications on new construction ships. The type of signal used depends on the noise level at the location and on the kind of sound desired.

BELLS AND BUZZERS

Bells used with alarm and warning systems may be either a.c. or d.c. operated, either watertight or watertight explosion proof construction, with either circular or cowbell-shaped gongs.

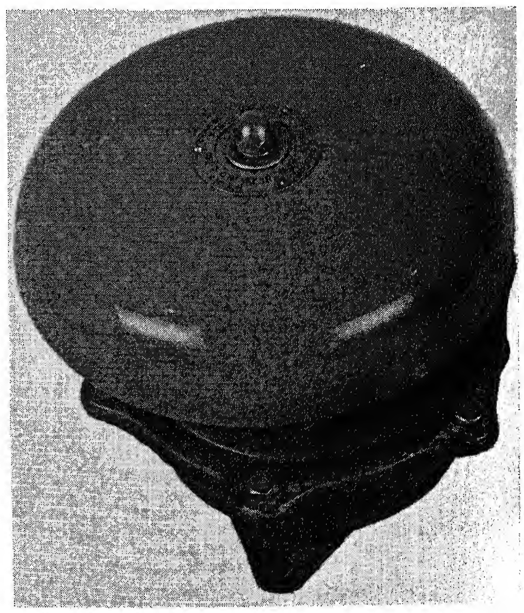
Alternating current bells have any one of three types of gongs; circular 3-inch diameter, circular 8-inch diameter, and the cowbell type (fig. 8-10).



27.2
Figure 8-10.—Cowbell type IC/B354.

Direct current bells have any one of thr types of gongs: circular 2 1/2-inch diamete circular 8-inch diameter (fig. 8-11), and cowbe type.

Buzzers are used only in relatively qui spaces. Buzzer, type IC/Z1D4 (fig. 8-12), i d.c. operated and has make and break contact



27.2
Figure 8-11.—IC/B2D4 bell.

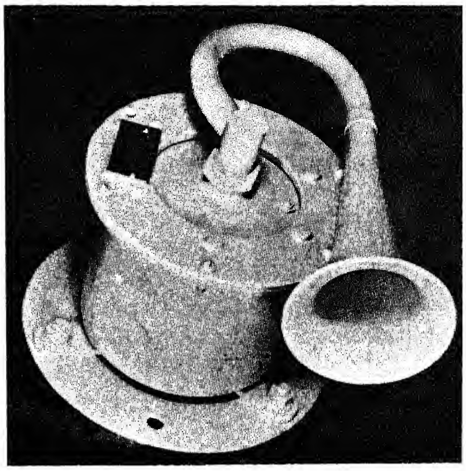
Buzzer, type IC/Z1S4, is a.c. operated and has no contacts.

HORNS AND SIRENS

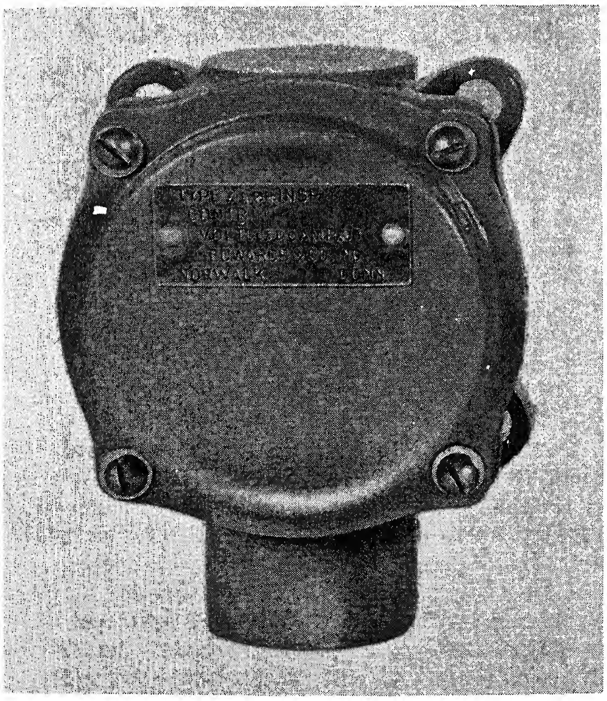
Nonresonated horns utilize a diaphragm actuated by a vibrating armature to produce sound of the required intensity.

Resonated horns (fig. 8-13) also use diaphragms and, in addition, have resonating projectors to give the sound a distinctive frequency characteristic. The resonated horn is designed in a variety of types differing as to intensity, frequency, or power requirements.

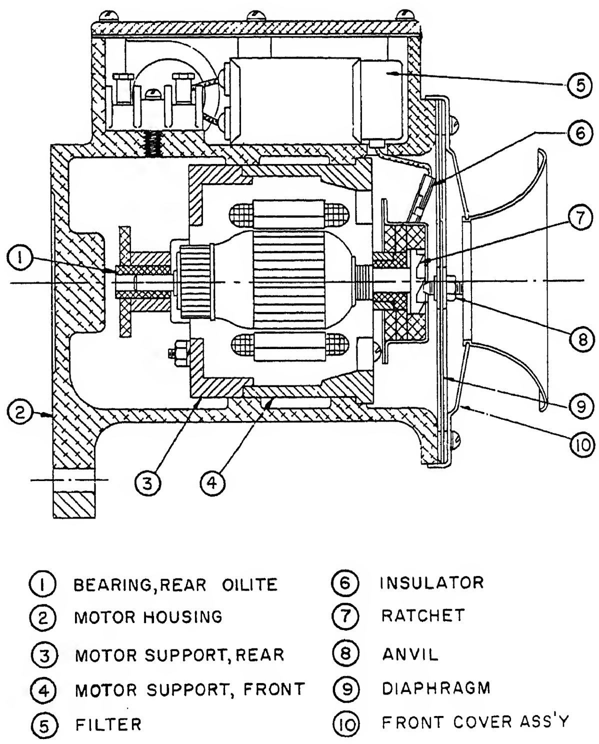
Motor-operated horns, or klaxons, utilize electric motors to actuate the sound-producing diaphragms. These horns are used in the diving alarm system aboard submarines, as well as in other circuits. Figure 8-14 is a cutaway view of a motor-operated horn.



27.300
Figure 8-13.—Resonated horn.



27.299
Figure 8-12.—IC/Z1D4 buzzer.



27.300
Figure 8-14.—Cutaway view of motor-operated horn.

Sirens are used in very noisy spaces to sound urgent alarms. The sound is produced by an electric motor driving a multiblade rotor past a series of ports or holes in the housing (fig. 8-15). The sound is made by the air as it is forced through the ports. The frequency of the sound depends on the number of ports, the number of rotor blades, and the speed of the motor.

ELECTRONIC SIGNAL UNITS

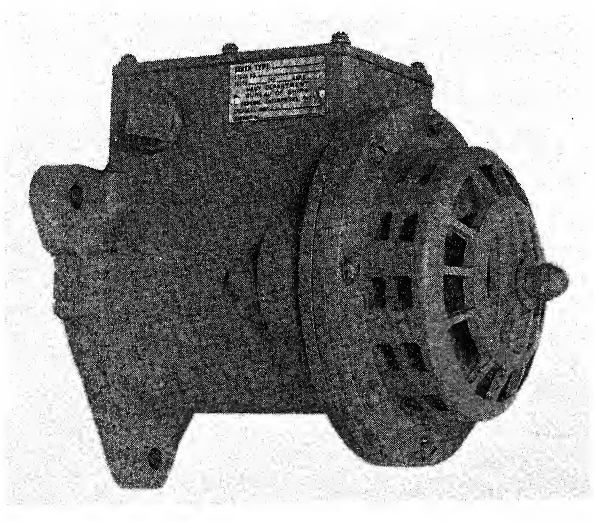
The type IC/E1D1 electronic signal unit (fig. 8-16) is designed as a power failure alarm. The unit contains an electronic solid state oscillator which produces an audible signal upon loss of power to the bus that is being monitored by the alarm unit.

The oscillator receives its power from a small nickel-cadmium battery which is maintained on a low charge when the monitored bus is energized. The unit will operate on 115 volts, d.c. or a.c. (60 Hz or 400 Hz), without modification.

27.302
Figure 8-16.—Electronic signal unit type IC/E1D1.

VISUAL SIGNALS

Visual signals are used in a great many alarm and warning systems as an additional means of identifying the alarm being sounded. Audible and visual signals are often used together In noisy spaces audible signals are supplemented by visual signals, and in brightly lighted spaces visual signals are supplemented by audible signals. In many instruments the same audible device is used in combination with several visual indicators. The principal types of visual signals are lamp-type indicators and annunciators such as those utilized in alarm switchboards and panels.

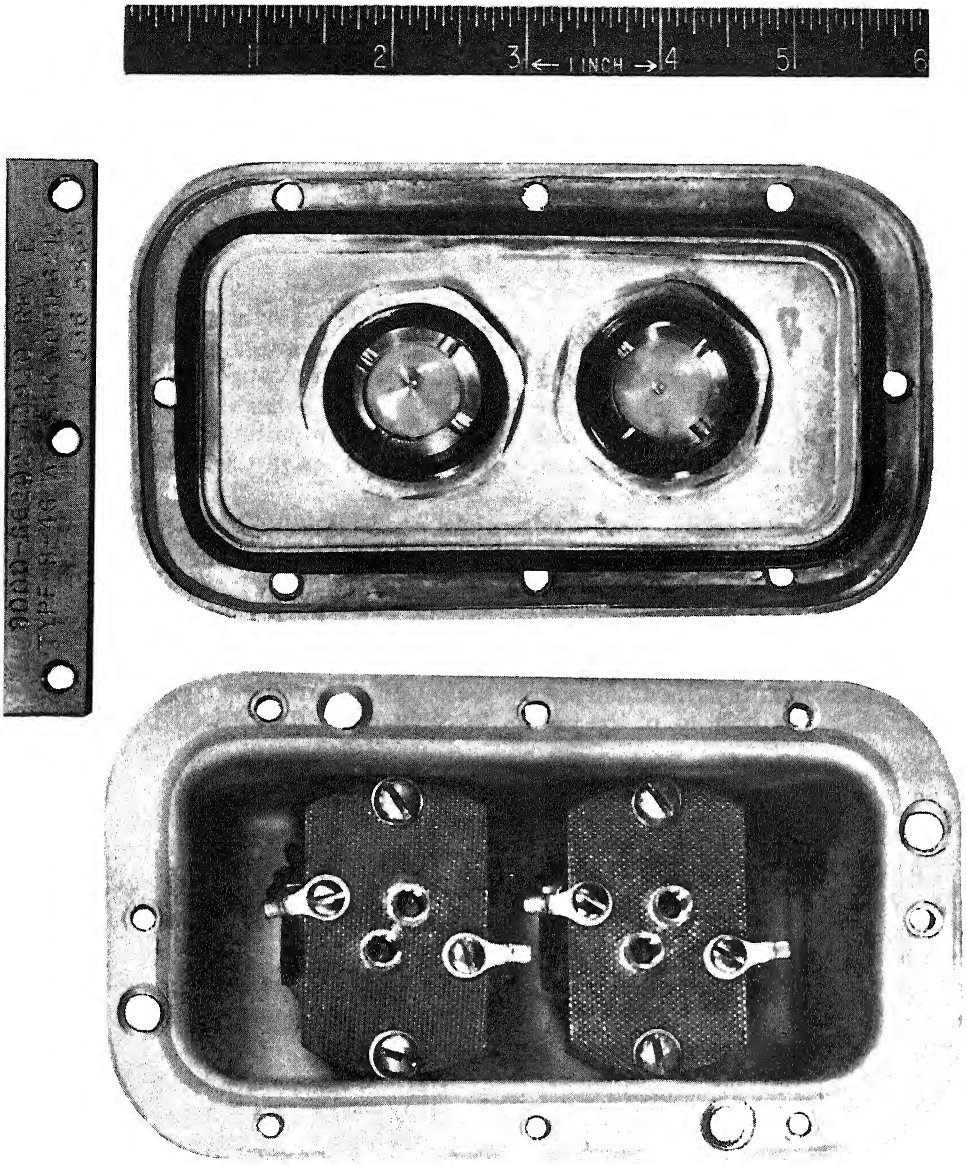


27.301
Figure 8-15.—Siren.

LAMP-TYPE INDICATORS

Standard watertight, lamp-type indicators are designed as single-dial, 2-dial, (fig. 8-17), 4-dial, or 6-dial units. Two lamps are connected in parallel and mounted behind each dial to provide protection against the loss of illumination in case one lamp burns out. A colored-glass disk and sheet-brass target engraved with the alarm identification are illuminated from the rear by the two lamps. Glass disks are furnished in eight standard colors, dependent on the application.

The power to the lamps is in parallel with the audible signal. When the audible signal sounds, the lamps illuminate the colored glass



27.303.1

Figure 8-17.—Lamp type indicator.

and brass target of the indicator and identify the alarm being sounded. This type of indicator is used with various alarm systems.

ALARM ANNUCIATORS

There are two basic types of alarm annunciators in general use. Each of these types supervises the circuit to which it is connected, providing alarm signals in the event of an alarm condition, and supervisory signals in the event of an open circuit between the indicator and the remote alarm sensor (switch).

The alarm annunciator measures the current flow through the circuit that is connected to it and differentiates between a normal, an alarm, or an open circuit condition. The circuit that is connected to the alarm annunciator has a

resistor attached across the last switch in the line of that circuit, as shown in figure 8-18. This resistor, called the supervisory resistor, permits a limited amount of current to flow through the circuit when the switch is open. This limited amount of current flow represents the normal circuit condition. Less current flow through the circuit or an open circuit results in supervisory signals being produced; more current flow through the circuit as when the switch closes, results in alarm signals being produced.

Alarm annunciators are used in conjunction with larger assemblies to form alarm switchboards or switchpanels which may supervise from 2 to more than 50 individual alarm circuits.

Two-Line Alarm Unit

The two-line alarm unit (fig. 8-19) provides equipment for supervising two circuits. Each circuit has an alarm-target relay, a supervisory-target relay, and a test-cutout switch. The two-line unit has two alarm target relays mounted side by side at the rear near the bottom of the unit

panel. Each alarm target relay has cont
which operate external alarm signals and
an indicator drum which projects a red ta
into the square opening in the face of the p
when the relay is operated. The two supervis
target relays have contacts that operate exte
supervisory signals and have indicator dr
that project a yellow target into the sq
openings in the face of the panel when the r
is restored.

Under normal conditions the current flov
through the supervisory resistor is suffic
to operate the supervisory relay but not
alarm relay. Therefore, neither the red al
target nor the yellow supervisory target is vis
in the openings in the front panel.

The test-cutout switch is a three-posi
switch. In the normal position the alarm indic
monitors the remote switch for alarm or sup
visory conditions. In the test position the sw
simulates an alarm condition and is used to
the components internal to the alarm indic
and the external alarm signals. THE T
POSITION VERIFIES ONLY THAT THE ALA

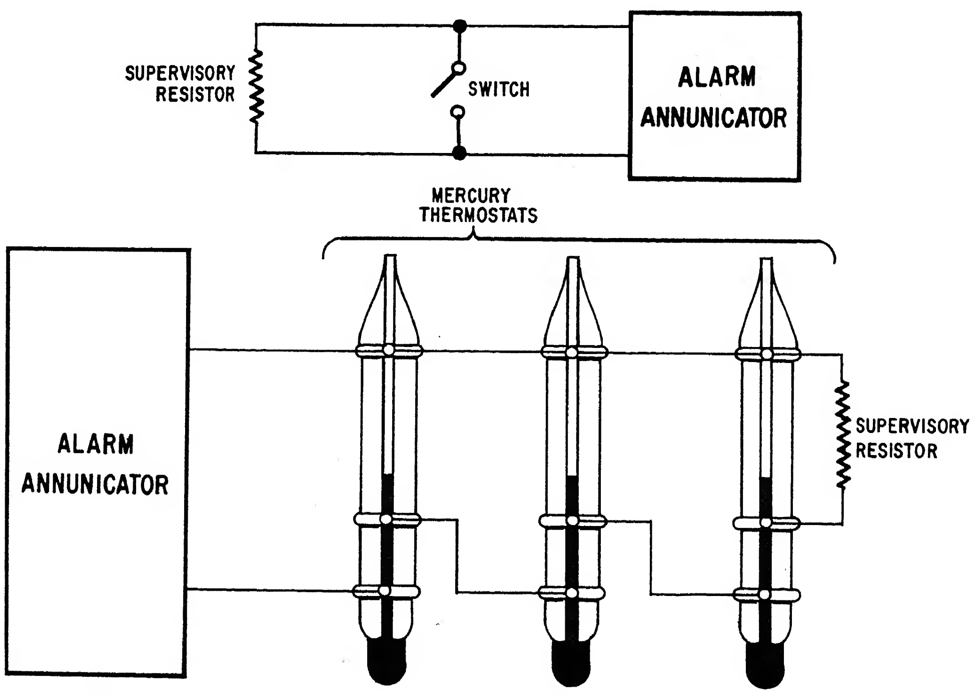
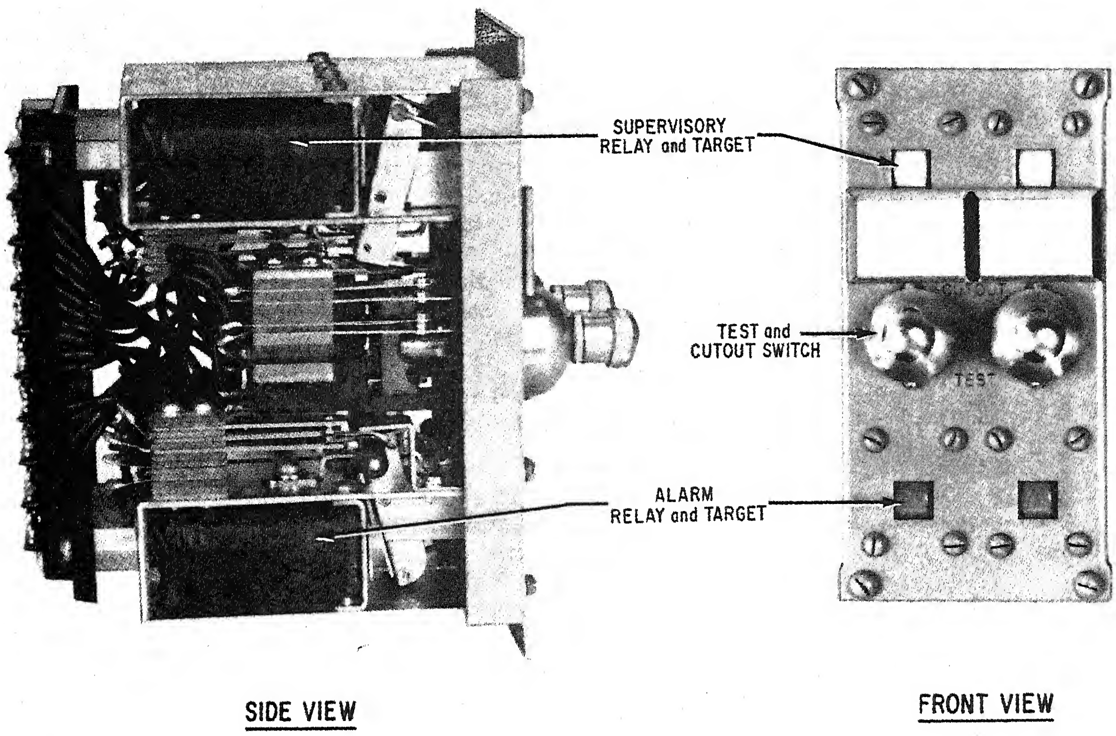


Figure 8-18.—Basic alarm circuit with supervisory resistor.



27.304

Figure 8-19.—Two-line alarm unit.

INDICATOR IS FUNCTIONING PROPERLY. IT DOES NOT VERIFY THAT THE REMOTE SENSORS WILL FUNCTION AS THEY WERE INTENDED. The cutout position is used to silence the external alarm or the supervisory audible signal.

IC/M Alarm Module

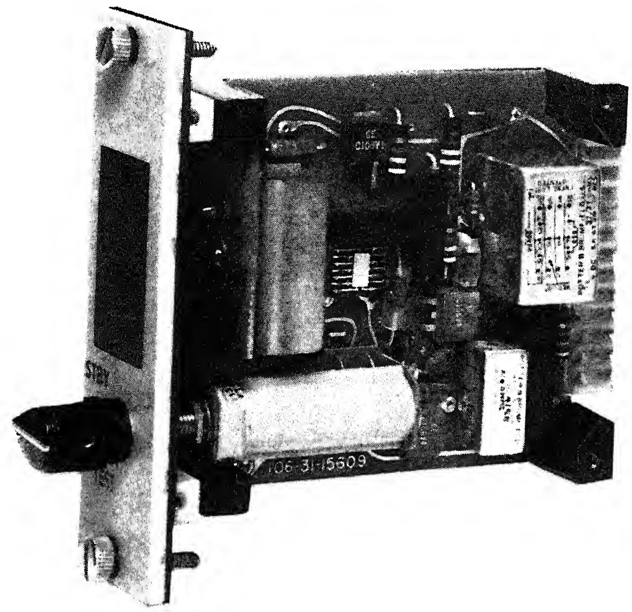
The IC/M alarm module performs the same function as the two-line alarm unit previously discussed. This unit is of more recent design than the two-line alarm unit, and it must be employed in an alarm switchboard which contains an audio generator. The audio generator produces audible signals for alarm and supervisory conditions.

The alarm module (fig. 8-20) has a manual selector switch for placing the module in either NORMAL, STANDBY, CUTOUT, or TEST modes and has a divided, lighted display, either half of which can show a steady or a flashing red light or no light, as required.

Under normal conditions, the upper lamp is "on steady," and the lower lamp is off (fig. 8-21). During an alarm condition, the upper lamp flashes and a wailing tone from the associated switchboard sounds.

To acknowledge an alarm, the switch is shifted to STANDBY and the audible alarm is silenced while both the upper and lower lamps are "on steady." After the alarm condition is cleared, the lower lamp flashes while the upper lamp goes out. A pulsating tone from the associated switchboard informs the operator to return the switch to the NORMAL position.

If the supervisory resistor on the circuit to the switch should open, the upper lamp goes out while the lower lamp is "on steady"; a pulsating tone from the associated switchboard alarm sounds when the module is in the NORMAL mode. Then, the alarm is silenced by placing the mode selector switch to CUTOUT. In this position the lamps indicate the same as they do for supervisory failure: top lamp out, lower lamp "on steady," no audible alarm.



140.122
Figure 8-20.—IC/M alarm module.

Placing the mode selector switch in the TEST position simulates an alarm condition. For this position the upper lamp flashes while the lower lamp is out. A wailing tone alarm sounds just as it does for an alarm condition in the NORMAL mode.

ALARM PANELS AND SWITCHBOARDS

Alarm panels and switchboards are used in conjunction with a majority of the alarm systems which monitor equipment or spaces, such as the low-lubricating oil pressure alarm, flooding and fire alarm systems.

ALARM PANELS

Alarm panels are produced in two standard sizes to supervise two or four remote sensors. The alarm panel enclosure houses one or two of the standard two-line alarm units. Alarm panels are usually mounted adjacent to the equipment which is monitored by the alarm sensors.

ALARM SWITCHBOARDS

There are two basic types of alarm switchboards. While both perform the same functions, one uses the two-line alarm units, and the other uses the IC/M alarm module. Alarm switchboards are usually installed in spaces that are continuously monitored, both in port and underway. Switchboards supervise a large number of sensor circuits which are installed in numerous locations throughout the ship, such as the mercury thermostats employed in IC circuit F.

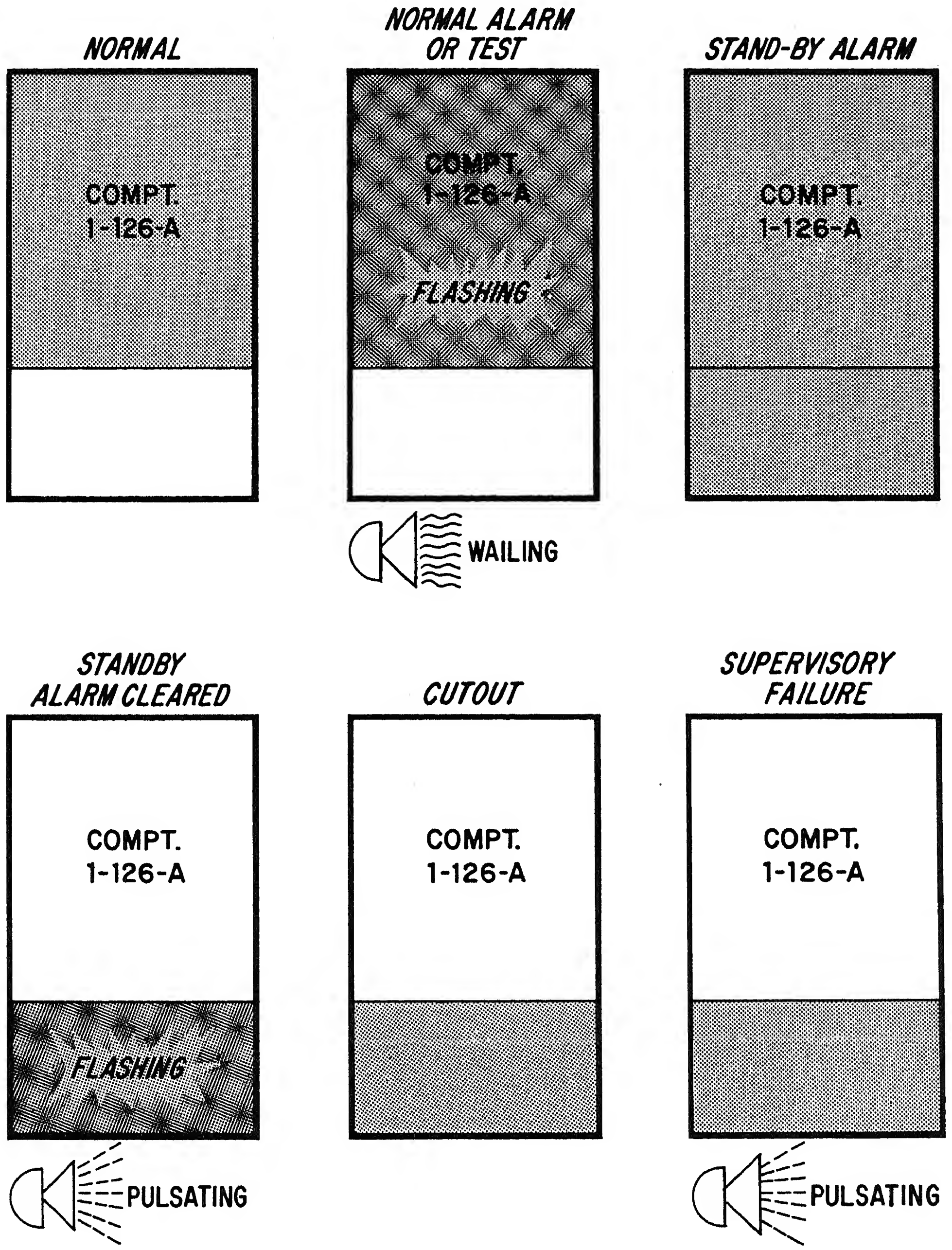
Two-Line Unit Alarm Switchboard

The two-line unit alarm switchboard is shown in figure 8-22. The upper section comprises the alarm panel which contains an alarm bell, a test light, a trouble buzzer, two ground-detector lamps, a power available lamp, a trouble test lamp, and a test key. An extension signal relay, capable of operating up to four alarm bells located at remote stations on the ship, is mounted at the rear of the alarm panel. As long as the power supply to the switchboard is maintained, the power available light at the center of the panel glows.

The lower section of the two-line unit alarm system switchboard (fig. 8-22) may consist of as many 10-line or 20-line panels as are necessary to accommodate the total number of high-temperature circuit F, or water-sprinkling circuit FH stations aboard the ship. Six 10-line panels capable of accommodating 60 lines are shown in figure 8-22. The switchboard apparatus for each two lines is mounted together in a removable alarm unit as shown in figure 8-19. Five of these 2-line units are arranged to make up a 10-line panel. A nameplate located above the cutout test key identifies the compartment or the spaces served by that line.

Type IC/SM Alarm Switchboard

The type IC/SM supervisory alarm switchboard (fig. 8-23) provides centralized monitoring of remotely located sensors. The features of the type IC/M alarm module, as previously explained, have been incorporated into this alarm switchboard.

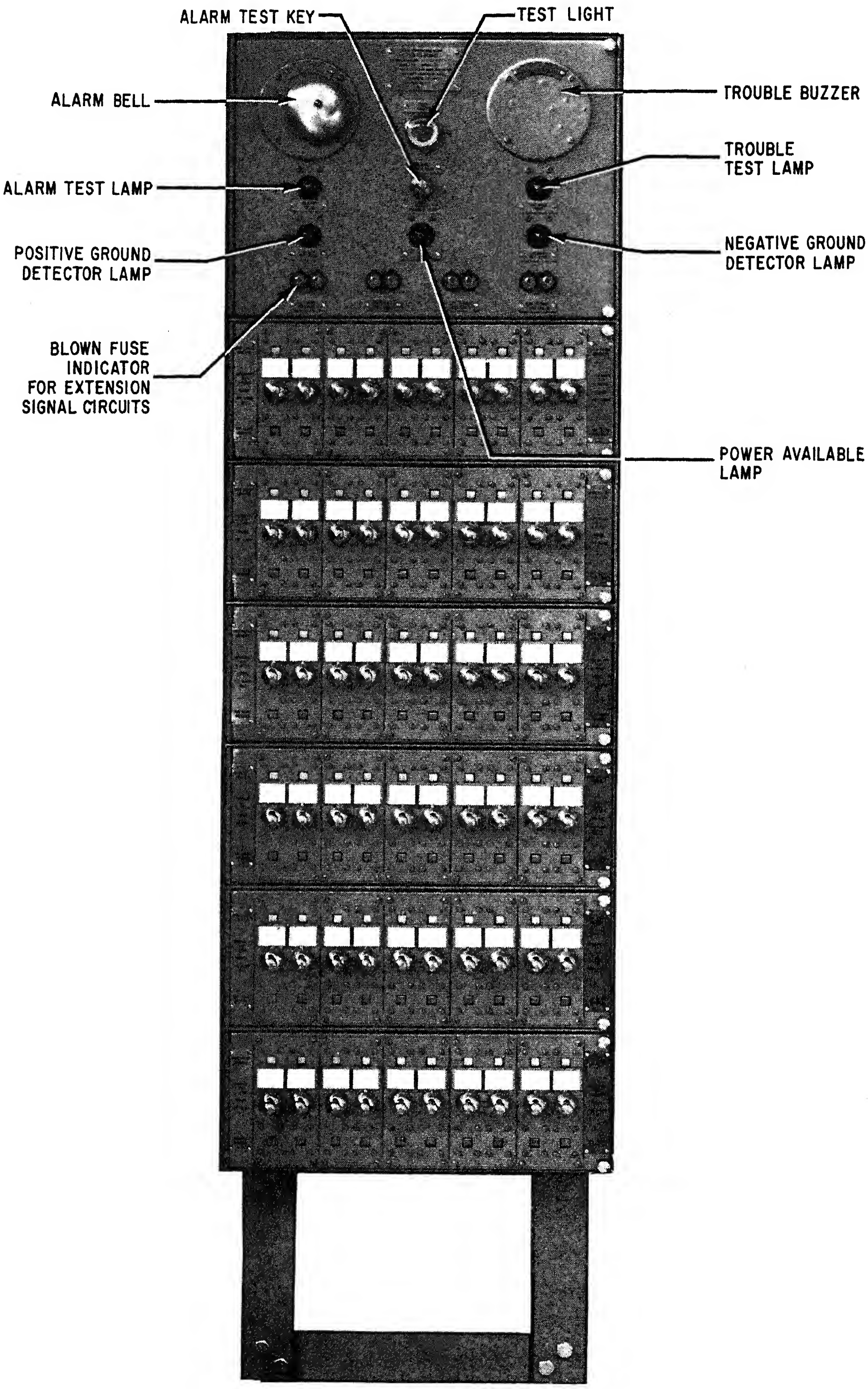


140.123

Figure 8-21.—IC/SM visual displays and audible outputs.

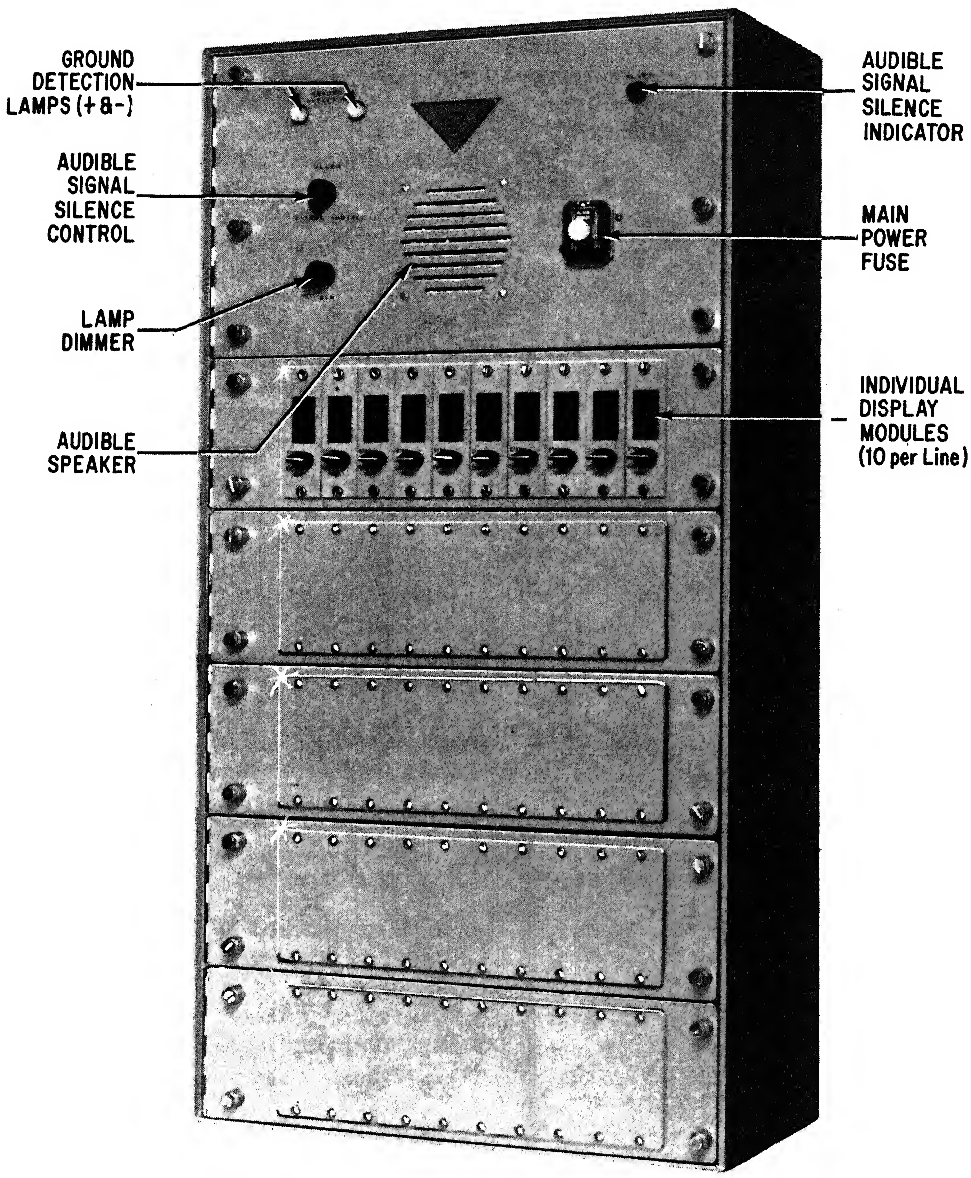
The upper section of the switchboard houses a speaker, signal generator, audible signal silence control switch, lamp dimmer, power supplies, buses, and ground detector lamps. The audible signal silence control switch is utilized to disable the audible alarm feature, while the visual alarm system remains fully operational. The audible signal silence indicator alerts personnel when the audible signal is not operational.

The lamp dimmer affects all the module indicating lights except the alarm condition lights which continue to flash at a full brilliance.



27.307

Figure 8-22.—Two-line unit alarm switchboard.



140.121

Figure 8-23.—IC/SM switchboard showing 10 active modules in place.

ALARM SYSTEMS

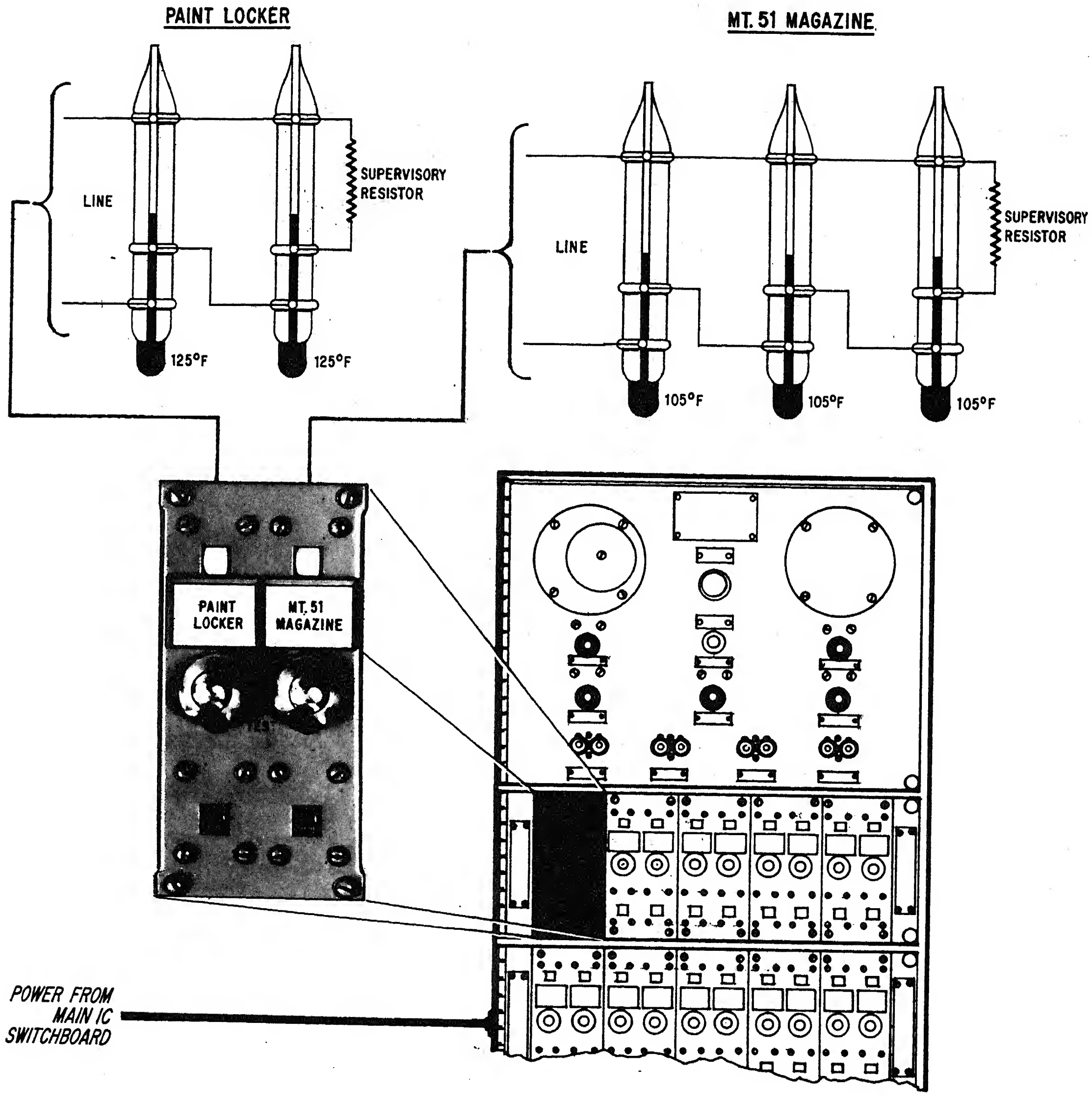
As previously stated, most alarm systems consist of a switch, power supply, and some type of indicating device, whether it be audible, visual, or a combination of the two. The particular equipment or component being monitored plus the different types of switches, indicating devices, and signals, employed in each circuit make it unique to other circuits. Several of the various alarm systems will be discussed in this section. Diagrams are included to aid you in understanding how the various components we have described in this chapter are employed to form a complete alarm system.

HIGH-TEMPERATURE ALARM SYSTEM

The high-temperature alarm system (circuit F) is used aboard ship to detect and warn of fires or overheated conditions in designated compartments and spaces. Usually this circuit employs the mercury-type thermostats and one of the two types of alarm switchboards (fig. 8-24). The thermostats are installed on the overhead and require a free circulation of air.

The 125° and 150° thermostats are normally installed in storerooms, paint lockers, and similar spaces that house combustible stores. The 105° F thermostat is normally installed in magazines.

As many thermostats as are needed for the prompt detection of a fire can be connected to any one line. If more than one thermostat is used in a compartment, only one supervisory resistor is required. When any one of the thermostats in the group is overheated, the alarm operates. These



27.379

Figure 8-24.—High-temperature alarm system.

thermostats, or groups of thermostats, are connected to the alarm switchboard by multiconductor cable. Each circuit on the alarm switchboard is marked to designate one compartment, and the thermostat, or group of thermostats, installed in each compartment is connected to the circuit marked for that compartment.

SPRINKLING ALARM SYSTEM

The sprinkling alarm system, circuit FH, is basically the same as the high-temperature alarm system except that water switches (fig. 8-6) are used instead of mercury thermostats.

COMBUSTION GAS AND SMOKE DETECTOR SYSTEM

The combustion gas and smoke detector system (circuit 4F) detects and warns of the presence of combustion gases or smoke. The alarm circuits operate similar to the high-temperature fire alarm circuits. A combustion gas and smoke detector (fig. 8-9) is used as the sensing device.

LUBRICATING-OIL, LOW-PRESSURE ALARM SYSTEM

The purpose of the lubricating-oil, low-pressure alarm system, circuits 1EC and 2EC, is to sound an alarm whenever the pressure in the lubricating-oil supply line to the main engine and reduction gear, or to the turbine-driven or diesel-driven generators, and other auxiliary machinery falls below a predetermined minimum limit. When the system is used for the main engines, the circuit is designated 1EC; when the system is used for either turbine-driven or diesel-driven generators and other auxiliaries, the circuit is designated 2EC. Both circuits are energized from individual switches on the local IC switchboard which is located in the appropriate engineroom.

An EC circuit includes one or more pressure type switches (fig. 8-2) installed in the lubricating-oil lines of the associated equipment. The alarm panel of the lubricating-oil, low-pressure alarm is located near the operating control board of the machinery on which the pressure switch is installed.

CIRCULATING-WATER, HIGH-TEMPERATURE ALARM SYSTEM

The circulating-water, high-temperature alarm system, circuits 1EW and 2EW, automatically indicates when the circulating-water temperature of the main propulsion diesel engines or the large auxiliary diesel engines rises above the predetermined maximum limit. When the system is used for the main engines, the circuit is designated 1EW; when the system is used for auxiliary engines, the circuit is designated 2EW. The circulating-water, high-temperature alarm system is usually combined with the lubricating-oil, low-pressure alarm system (fig. 8-25) and consists of temperature-operated switches (fig. 8-3) located in the circulating water lines of the engines. A rise in temperature above a predetermined point causes the alarm to sound.

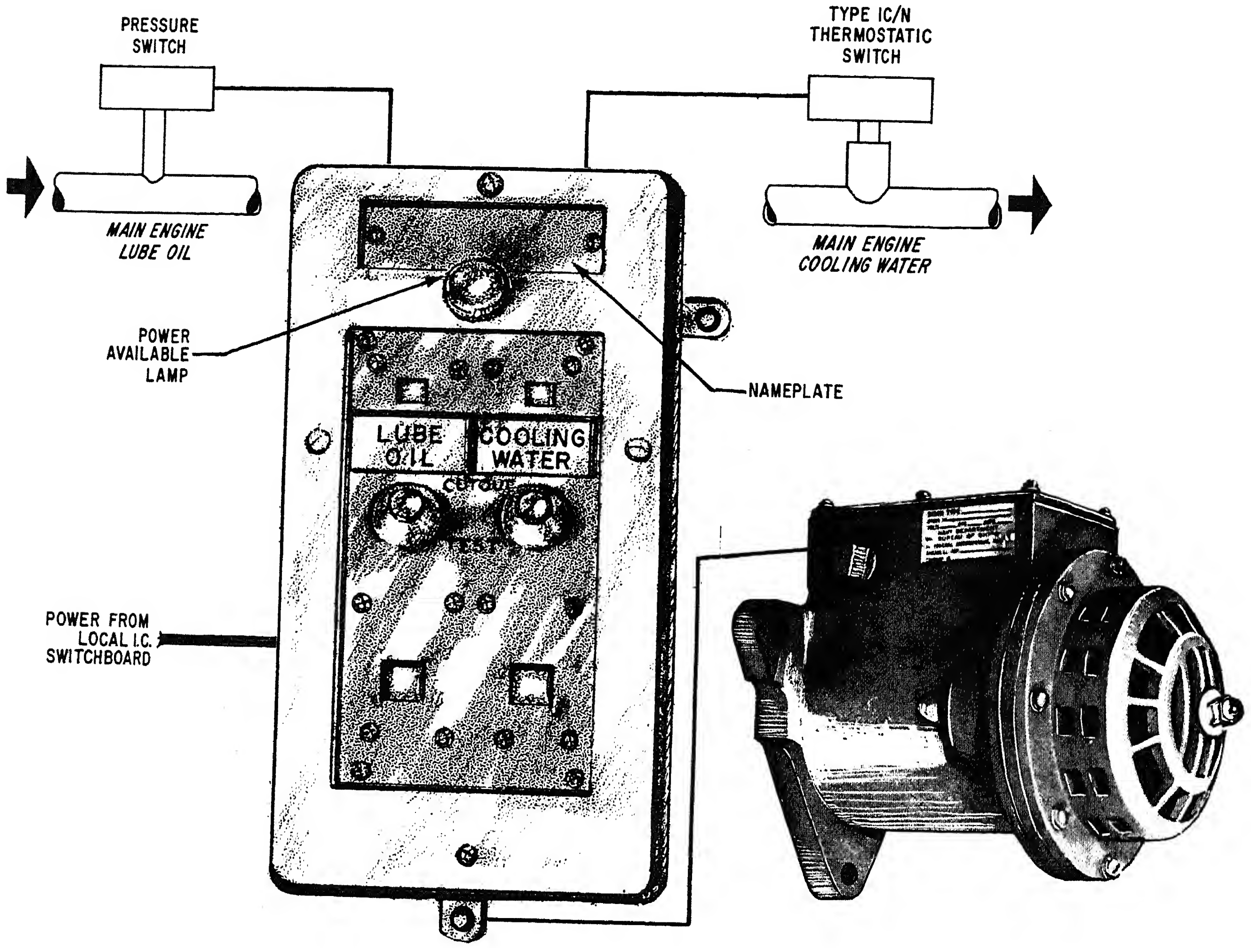
GENERATOR AIR HIGH-TEMPERATURE ALARM AND THE GENERATOR BEARING HIGH-TEMPERATURE ALARM SYSTEMS

The generator air high-temperature alarm system, circuit 1ED, provides a means of indicating high temperature of the cooling air exhaust of generator sets rated at 500 kW and above. The system consists of type IC/N thermostatic switches, which energize visual and audible signals whenever the temperature of the circulating air rises above a predetermined limit.

The generator bearing high-temperature alarm system, circuit EF, provides a means of indicating high temperatures in the bearings of generator sets of 200 kW and above. Thermostatic switches energize visual and audible signals when a bearing temperature rises above a predetermined limit.

SYSTEMS MAINTENANCE

As a rule the principles of operation of alarm and warning systems are simple. However, because of the large number of systems installed on most ships, this equipment will require a good deal of attention from maintenance personnel.



27.38(

Figure 8-25.—IC alarm circuits 1EC and 1EW.

Maintenance should be accomplished as instructed by the applicable MRC's with attached Equipment Guide Lists and manufacturer's technical manuals.

Operators, watchstanders, and maintenance personnel should remember that when you use test-cutout switches on the alarm panels and switchboards to test an alarm circuit, only the alarm indicators and associated visual and audible signals will be tested. This type of test does not verify that the sensing device employed in th circuit will operate at the proper value. Th sensing device could be, as is the case in al too many instances, completely inoperable; ye the circuit would test good from the alarm panel A regular program should be undertaken to tes alarm circuits on a regular basis by duplicating as closely as possible, the conditions which th alarm system was designed to indicate. By doin this, the entire system, including the sensin device and its operating point, is verified.

CHAPTER 9

SHIP'S INDICATING, ORDER, AND METERING SYSTEMS

The modern naval vessel is an extremely complex machine. To properly operate a ship, watch personnel require vast quantities of information relative to conditions within and without the ship.

The Officer of the Deck must have a rapid means of transmitting orders to the throttleman and to the man on the helm, etc., and just as rapidly, he must know that his orders have been received. The actual speed and position of the ship, the distance traveled, the speed of the main engines, the wind speed and direction, the amount of fuel remaining aboard, the salinity of the feedwater, and a host of other information, are of great interest to personnel throughout the ship. Ship's Indicating, Order, and Metering Systems measure and transmit much of this information throughout the ship.

TANK LEVEL INDICATING SYSTEMS

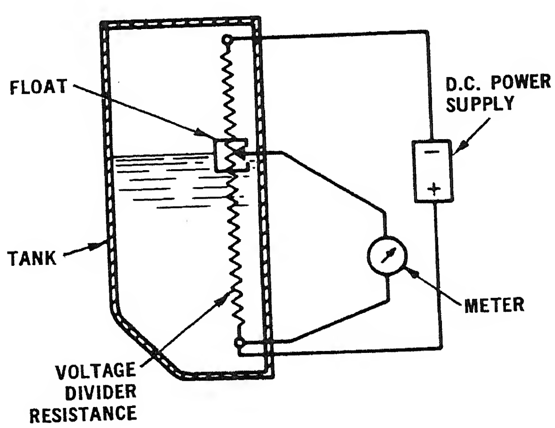
The tank level indicating system, circuit TK, measures the amount of liquid in various shipboard tanks and transmits that information, electrically, to remote locations.

A typical tank level indicator consists of (1) a transmitter, which measures the liquid level in a tank and converts that information to an electrical signal; (2) a power supply; (3) an indicator meter or meters, calibrated in gallons or pounds of liquid; and, in some cases, (4) an alarm circuit that warns of unusually high or low liquid levels within the tank.

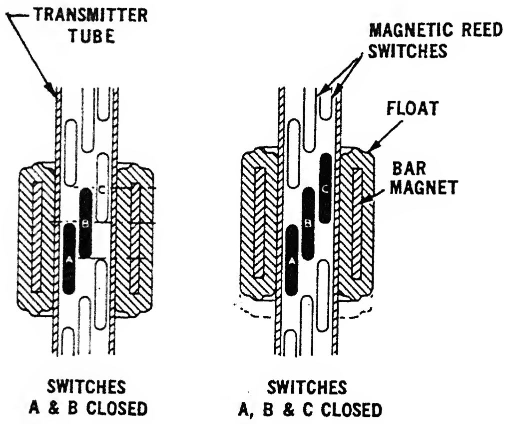
Several different types of tank level indicating systems, whose transmitters employ different principles of operation to detect liquid level, are utilized aboard Navy ships. Of these systems the type IC/MC, or GEMS, tank level indication systems has proven to be one of the most accurate and reliable.

The GEMS tank level indicating system functions essentially the same as the basic circuit shown in figure 9-1. The movement of the float causes the resistance of the voltage divider network to vary. In the circuit shown, the low level is indicated when there is less voltage drop between the contact points of the meter. A full tank would be indicated when all of the voltage drop across the resistor is being measured.

Instead of having the float connected mechanically to the slider of a variable resistor as shown in figure 9-1, the actual transmitter of the GEMS system functions through magnetic mechanisms. The transmitter consists of a waterproof tube. Contained within the tube are many magnetically operated reed switches and a voltage divider network. A magnet is encapsulated within the material of the float. As shown in figure 9-2, the upward movement of the float and magnet within the tube results in the operation of the enclosed reed switches. The reed switches are connected to the voltage divider network in such



104.64
Figure 9-1.—Basic circuit for liquid level indicator.



27.381
Figure 9-2.—Operational sequence of magnetic reed switches as float travels along transmitter tube.

a way that, as each reed switch closes for an upward movement of the float, a quantity of resistance will be added, thereby increasing the voltage drop across the transmitter.

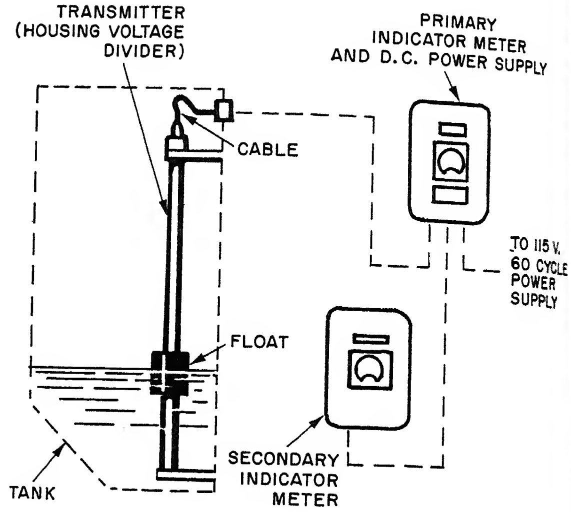
As might be expected, there is a "stepping" motion of the meter pointer as each quantity of resistance is added to or subtracted from the voltage dropping circuit. Since there are many reed switches in proportion to the length of the transmitter and since the change in the quantity of resistance is small as each reed switch is actuated, the "stepping" motion is barely discernible.

Figure 9-3 illustrates a typical GEMS liquid level indicator system with primary and secondary indicator meters.

The GEMS system can distinguish between two liquids of different specific gravities, such as fuel oil and water, when a float material is used that will float in the denser liquid but not in the less dense. Transmitters with this type float are used in compensated fuel oil tanks to distinguish between the fuel and water and indicate only how much fuel remains.

SAFETY

When maintenance is being performed on any tank level indicating system, and a tank will be



104.65
Figure 9-3.—Diagram of a GEMS liquid level indicator system.

entered, be sure that the Gas Free Engineer has tested the tank before maintenance personnel enter. Follow all safety directives precisely.

SALINITY INDICATOR SYSTEM

The salinity indicator system, circuit SB, indicates the amount of salinity in water systems aboard ship. The system is a necessity aboard ship because all freshwater, when underway, is made from seawater. Excessive salinity in the boiler feedwater causes pitting of the tubes and rapid deterioration due to electrolysis. Salinity indicators are usually provided in the enginerooms and the firerooms to check the condensate from the main and auxiliary condensers. The indicators are also provided for the evaporator plants to indicate the degree of purity of the water at various selected points in the distilling system.

The salinity indicator system operates on the principle that an increase of the electrolytic impurities (principally salt) in water increases the electrical conductivity of the water. If two electrodes are immersed in the water being tested and a stable alternating voltage is applied

across the electrodes, a stable alternating current will flow through the water if the impurity content and the temperature of the water remain unchanged.

The amount of current flow is indicated on a meter whose scale is graduated in chloride equivalent parts per million. If the saline content of the water increases because salt water is leaking into the system or because of faulty operation of the distilling plant, the conductivity between the electrodes increases, and the meter reading increases by an amount proportional to the increase in salinity.

A complete salinity indicator system consists of one or more salinity cells which contain the electrodes, a salinity indicator panel which contains the meter, power supplies, control equipment, and, in some cases, alarm circuitry which warns of unusually high salinity conditions.

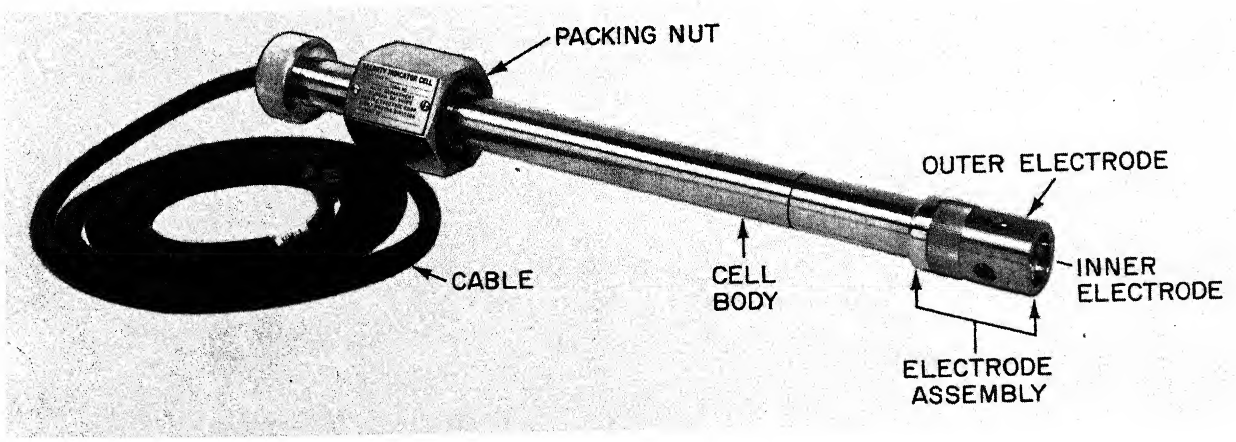
SALINITY CELL

The salinity cell (fig. 9-4) consists mainly of a 3-conductor interconnecting cable, packing nut, cell body, electrode assembly, and an automatic temperature-compensating resistor housed within the cell body.

The packing nut and cell body properly support the electrode assembly in the ship's piping system and, along with the cell valve (discussed below), form a watertight seal. They also provide a means of inserting and removing the cell from the ship's piping systems without loss of liquid.

The electrode assembly consists of an inner electrode, outer electrode, and the automatic temperature compensating resistor. The inner electrode consists of a platinum-plated button placed on the end of the cell body but insulated from it. The outer electrode is a platinum-plated cylinder that is connected to the cell body and surrounds the inner electrode. The outer electrode is pierced with holes to vent any gases trapped between the two electrodes and to permit free circulation of water over the electrodes.

Two factors actually control the conductivity of the impure water. The first factor, the salinity, has been discussed. The second factor is the temperature of the solution. As the temperature of a saline solution increases, its conductivity decreases. This phenomenon causes the salinity system to indicate an impurity level that is less than that actually present. To compensate for this action, an automatic temperature-compensating resistor is placed inside the cell body. By its location within the cell, the automatic temperature-compensating resistor maintains its temperature at that of the surrounding water. The resistor's conductance varies by a factor that is proportional to diluted seawater. Since both the resistor and the diluted seawater are affected by temperature in a like manner, the resistor is connected in the circuit so that the net result of a temperature change is zero. In this way, the salinity equipment continually indicates the actual impurity content through a temperature range of 40° F to 250° F.



7.150X

Figure 9-4.—Salinity indicator cell.

CELL VALVE

As stated earlier, the cell valve, in conjunction with the packing nut and cell body, provides the means to insert or retract the cell from the ship's piping systems without loss of water while maintenance is being performed. Figure 9-5 provides a view of a salinity cell installed in a ship's piping system through a cell valve.

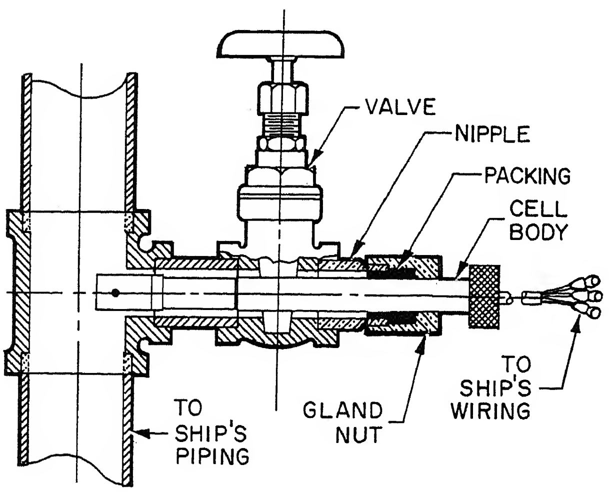
SALINITY INDICATOR PANEL

As previously stated, a salinity indicator panel measures the conductivity of the water being tested by the salinity cell and displays this information as a reading on a meter. In some cases the indicator panel provides audible and visual alarms if the salinity of the water under test exceeds specified limits. There are many different types of salinity indicator panels available; two are discussed below.

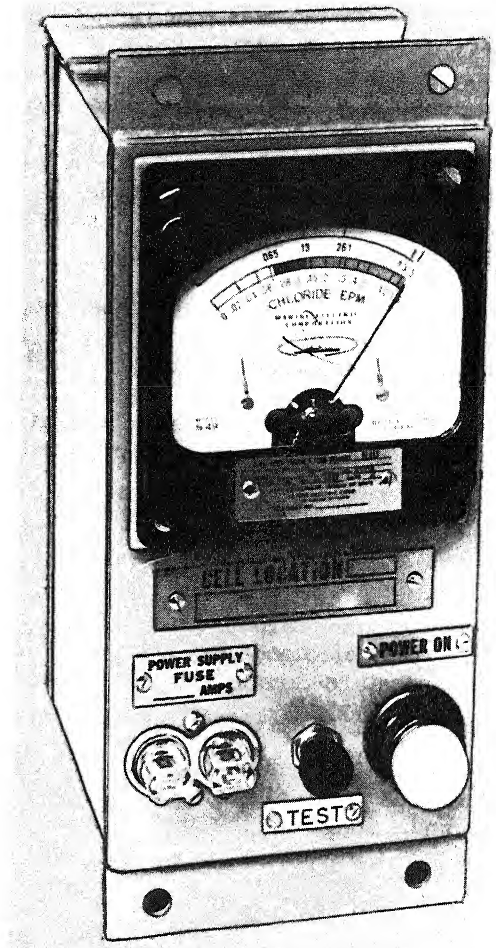
IC/E1U-S3 Salinity Indicator Panel

The IC/E1U-S3 salinity indicator panel (fig. 9-6) monitors the conductivity of one salinity cell continuously. This panel may be used in a system that contains only one salinity cell such as an electronics cooling water system, or it may be used in a larger system where a continuous reading of one particular cell of a system is desirable. The unit contains a meter, a test pushbutton, calibration resistor network, and an isolation transformer.

The test pushbutton and calibration network serve as a self-check circuit. This self-check circuit serves only to test the meter's accuracy. When the test pushbutton is depressed the meter should read 1.7 ppm. If it does not, the calibration resistor contained within the unit should be



27.382
Figure 9-5.—Salinity cell installation.



27.383
Figure 9-6.—IC/E1U-S3 indicator panel.

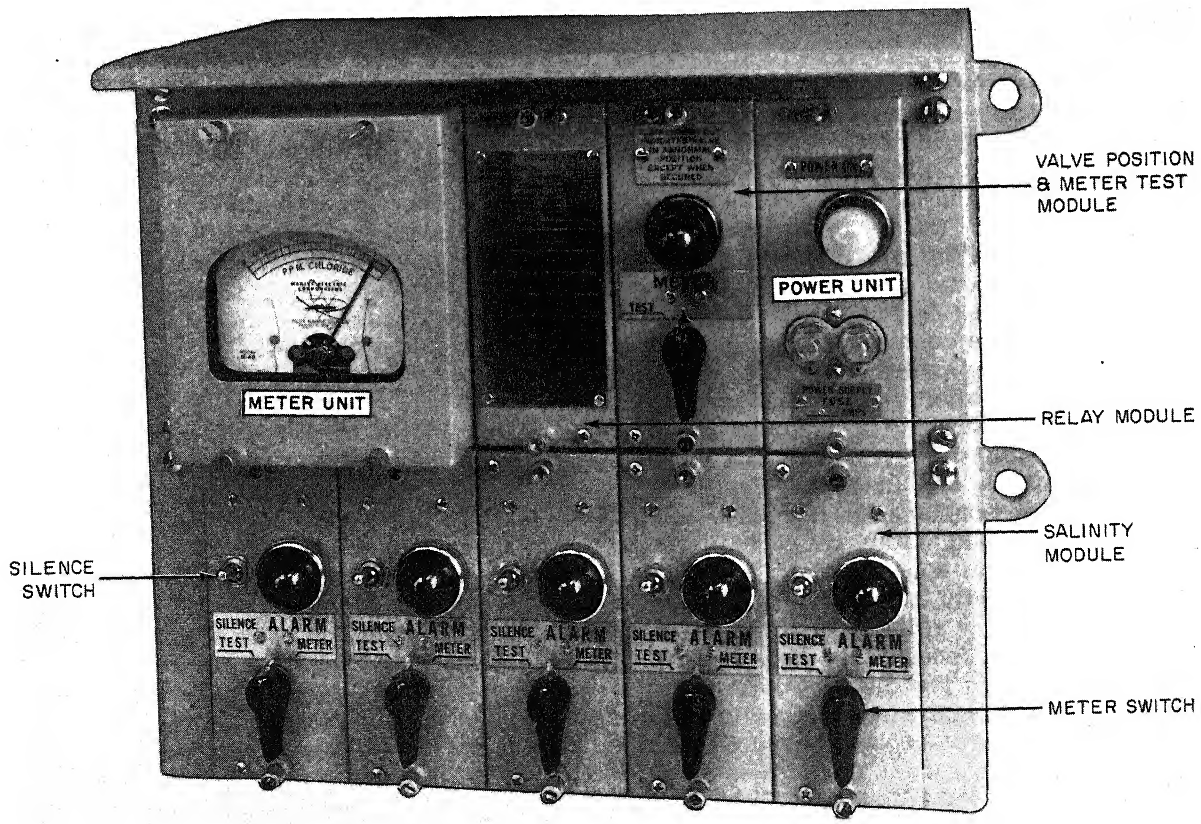
adjusted by maintenance personnel for this reading.

As the electrodes of each salinity cell are immersed in water, leakage current may flow from the electrodes through piping to the ship's hull (ground). In fact, the outer electrode of the salinity cell makes actual metallic contact with the cell body and packing nut. When the cell is installed in a ship's piping system, a very low resistance path is provided for the 115 VAC applied to the outer electrode to ground. The isolation transformer of the unit isolates the ground paths provided by the salinity cells from the ship's supply voltages. In addition, it does not allow the ground paths of one cell to affect the reading of another cell, and it reduces the electrical shock hazards for personnel associated with this system.

IC/D5RM Salinity Indicator Panel

The IC/D5RM salinity indicator panel (fig. 9-7), is designed to monitor five salinity cells of a distilling plant, although it may be used in a condensate system. The panel has an alarm system to warn of high salinity conditions and circuitry to control a solenoid trip valve which is used to dump the distillate coming from the plant in the event its salinity exceeds a specified amount. The panel is modular in construction and contains a power unit, a meter unit, a valve position and meter test module, a relay module, and five identical salinity modules.

Please refer to figure 9-7 as we discuss the IC/D5RM salinity indicator panel in the succeeding paragraphs.



7.151

Figure 9-7.—IC/D5RM salinity indicator panel.

The power unit has a white power-on indicator lamp and two indicating fuse holders. Contained within the unit is a transformer which provides power to operate the salinity modules and salinity cells. The transformer also isolates the grounds inherent to the salinity cells, as discussed earlier.

The salinity modules, of which there are five, continuously monitor the salinity cell connected to it. If its alarm setpoint is exceeded, the module signals by flashing its red indicator light and by sounding an external audible signal that is common to all five modules.

A high salinity condition is indicated initially by a flashing red indicator light and an external audible alarm. To clear the external alarm for other incoming alarms, the silencing switch on the module is placed in the SILENCE (down) position, causing the red indicator light to glow steadily. When the high salinity condition is corrected, the red light again begins to flash to remind the operator to return the silencing switch to the NORMAL (up) position.

The 3-position, spring-loaded meter switch has a NORMAL (center) position, a TEST position, and a METER position. When placed in the TEST position, the meter switch causes the cell to behave as though a high salinity condition exists—energizes the alarm circuit causing the red alarm light to flash and the alarm relay to sound the external alarm. The meter switch, when placed in the METER position, connects the meter unit to the associated salinity cell, and a salinity reading is indicated on the meter.

The relay module contains an external alarm relay and a 2-second delay relay. The external alarm relay is controlled by the salinity modules. With the silence switch in the NORMAL position, an alarm condition in any one of the salinity modules will cause the external alarm relay contacts to close, sounding the external audible alarm. The 2-second delay relay is used in conjunction with the solenoid trip valve. Any one of the five salinity modules may be used to actuate the time delay relay. Usually, the wiring inside the panel is connected so that the salinity module that monitors the distillate, after it has passed through the final stages of the distilling plant, is selected to control the time delay relay. If an alarm condition lasts for more than 2 seconds, in the selected module, the 2-second time delay relay causes the solenoid trip valve to be deenergized (tripped). The tripping of the solenoid trip valve causes the distillate to be dumped to the bilges or overboard. When the alarm condition is cleared, the solenoid trip valve must be manually reset. A 2-second delay relay is used so that spurious alarms in the selected module will not trip the solenoid valve.

The valve position and meter test module has a green valve position indicator lamp and a meter test switch. The dual purpose of the unit is to indicate whether the solenoid trip valve is in the NORMAL or TRIPPED position and to provide a means of testing the meter unit.

When the solenoid trip valve is in the NORMAL position, the green indicator lamp is illuminated steadily; when in the ABNORMAL position, the green alarm light flashes; and when the valve is reset manually, the green alarm light is again lighted steadily.

The meter test switch, when placed in the TEST position, connects the meter unit to a circuit which simulates a known salinity condition (1.7 ppm) to check the calibration of the meter.

SAFETY

As previously discussed, dangerous potentials are present on all the surfaces of the salinity cells. The ENTIRE SYSTEM should be deenergized and RED-TAGGED when any maintenance is performed on the salinity cells or inside the salinity panel. Also, personnel should be cautioned prior to working on salinity cells to take adequate precautions to avoid injury from hot pipes, steam and/or high pressures which may be present in the ship's piping systems.

RUDDER ORDER AND RUDDER ANGLE INDICATOR SYSTEMS

The rudder order system (circuit L) and the rudder angle indicator system (circuit N) utilize synchros, as do many other IC circuits, to transmit information. Synchros are electromagnetic devices which are used primarily to transmit angular position data. Physically, as shown in figure 9-8A, a synchro resembles a small electric motor, but functions as a transformer, the primary of which is connected to the shaft whose angular position is to be transmitted. The secondary of the synchro surrounds the primary of the synchro. When an a.c. voltage is applied to the primary, its angular position in respect to the secondary determines the voltage induced in the secondary. Each time the angular relationship between the synchro's primary (rotor) and secondary (stator)

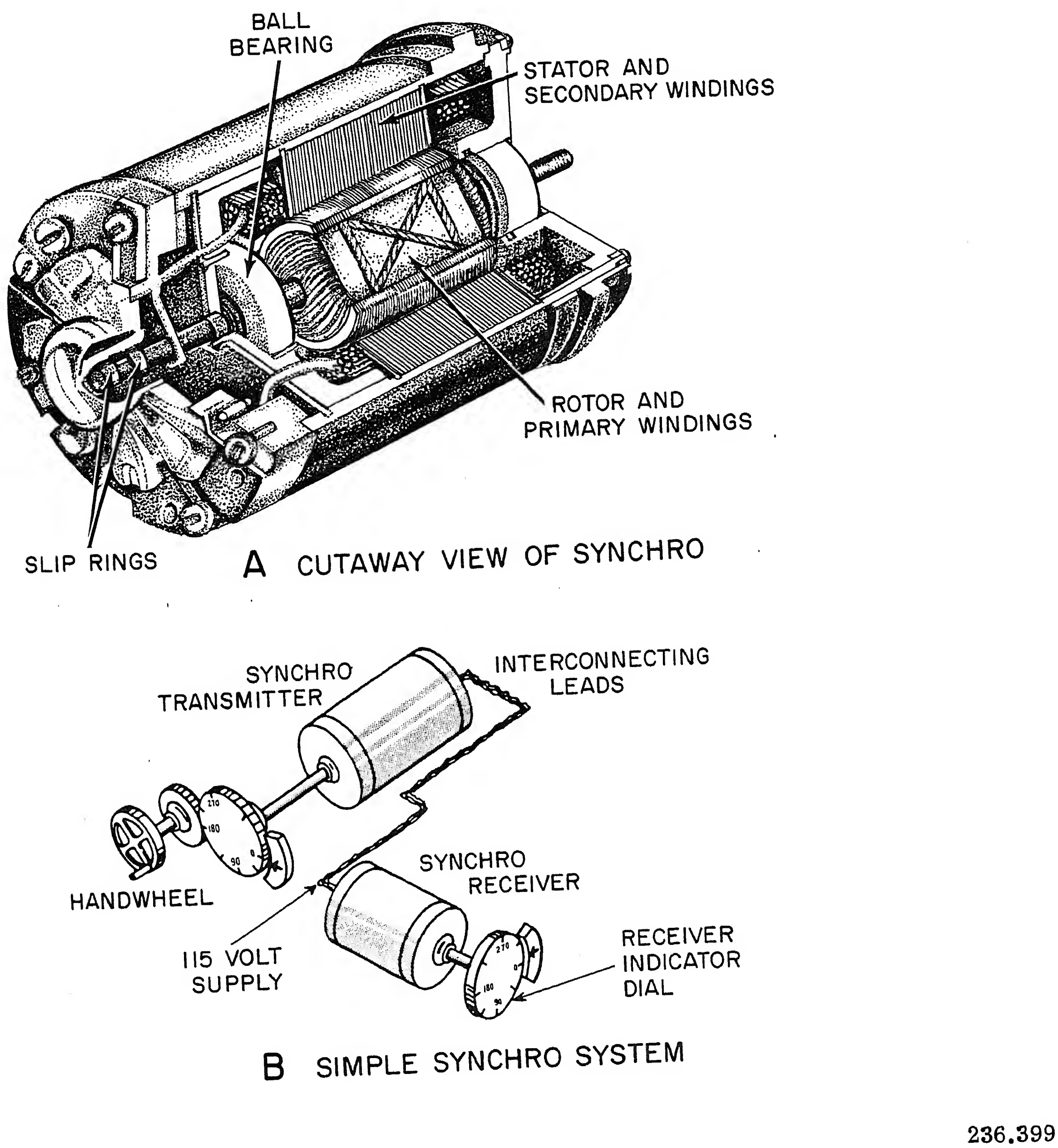


Figure 9-8.—Synchros.

is changed, the induced voltages in the stator change.

Figure 9-8B shows a simple synchro system. The rotor of the transmitter and the rotor of the receiver are connected to the a.c. supply voltage. The stator of the receiver is connected to the stator of the transmitter. When the handwheel in figure 9-8B is turned, the rotor-stator angular positions of the transmitter and the receiver are no longer the same, the voltages induced in their respective stators will not be the same. These two different stator voltages result in an unbalanced condition between the transmitter and receiver. As a result of this unbalance, a torque is produced electro-magnetically between the rotors and the stators of the transmitter and the receiver. The rotor of the transmitter is held in position which causes the receiver's rotor to move to a position to eliminate the unbalanced

condition. As a result, the movements of the rotor of the transmitter are followed by the rotor of the receiver. The above information is a very simple explanation of synchro principles. Detailed information concerning the operation and maintenance of synchros is contained in Basic Electricity, NAVPERS 10086, Synchros, Servo and Gyro Fundamentals, NAVPERS 10105, and Military Standardization Handbook for Synchros, MIL Hdbk 225-(AS).

RUDDER ORDER SYSTEM

Under normal conditions the rudder of a ship is controlled remotely from the helm on the bridge. If the remote steering control system should fail, the rudder order system (circuit L) electrically transmits rudder orders to the steering gear room where watch personnel can control the steering gear.

The two major units of the rudder order system serve a dual purpose in that components of both units are used in conjunction with the rudder angle indication system (circuit N).

The rudder order transmitter-rudder angle indicator (fig. 9-9) is installed on the bridge to transmit the ordered rudder angle to watch personnel in the steering gear room. This indicator contains a synchro receiver, which is a component of the rudder angle indicating system (circuit N), and a synchro transmitter, which is a component of circuit L.

The rudder order-rudder angle indicator (fi 9-10), installed in the steering gear room, contai two synchro receivers. One of the receivers used in conjunction with the rudder indicati system (circuit N). The other receiver, a con ponent of circuit L, receives the transmitt order from the bridge unit.

The control knob on the rudder ord transmitter-rudder angle indicator (fig. 9-9 manually positions the pointer marked ORD well as the rotor of the synchro transmitter the bridge unit. The transmitter produces a sign which is sent to the circuit L receiver in tl steering gear room. The signal causes the pointe (ORD) on the receiver to move automatically a position that corresponds to the position of tl pointer on the bridge.

The pushswitch in figure 9-9 is used i conjunction with a bell in the steering gear roon Each time a new rudder order is transmitte the pushswitch is depressed to alert steerin gear watch personnel to the new order.

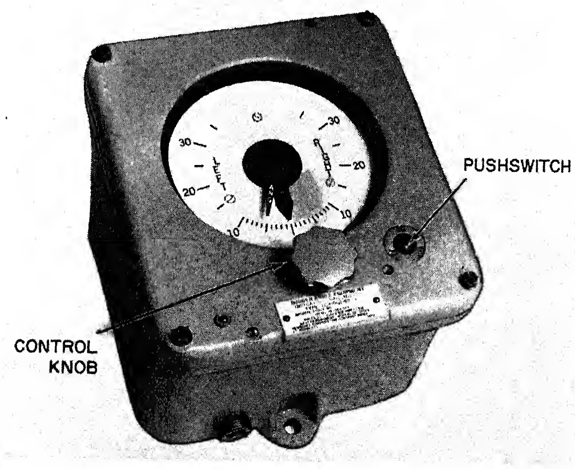


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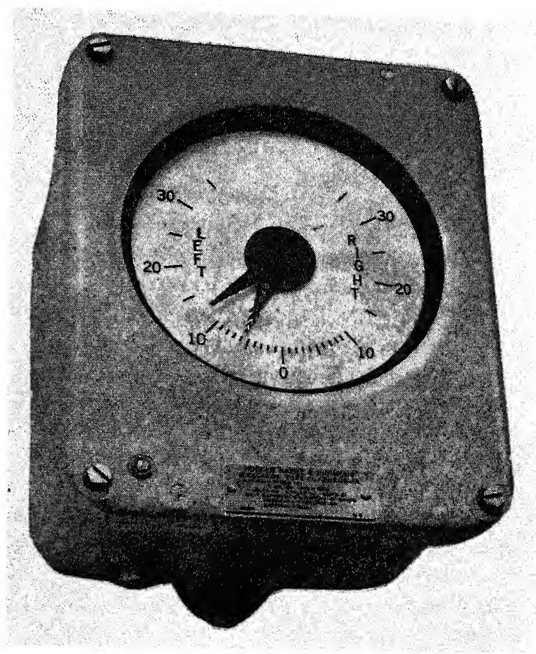
Figure 9-9.—Rudder order transmitter-rudder angle indicator.



7.126.5

Figure 9-10.—Rudder order-rudder angle indicator.

RUDDER ANGLE INDICATOR SYSTEM

The rudder angle indicator system (circuit N) electrically transmits the actual angular position of the ship's rudder to designated stations throughout the ship.

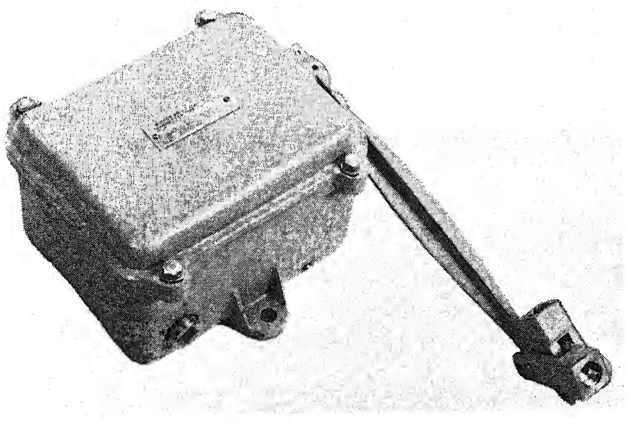
The rudder angle transmitter (fig. 9-11) consists of a synchro transmitter mechanically linked to the rudder stock in such a manner that the synchro transmitter shaft follows the movement of the rudder. It transmits rudder angle data to various ship's indicators.

The rudder angle indicator (fig. 9-12) consists of a fixed dial and a pointer mounted on the shaft of a synchro receiver. The synchro receiver positions the pointer on the dial face in response to the transmitted rudder angle.

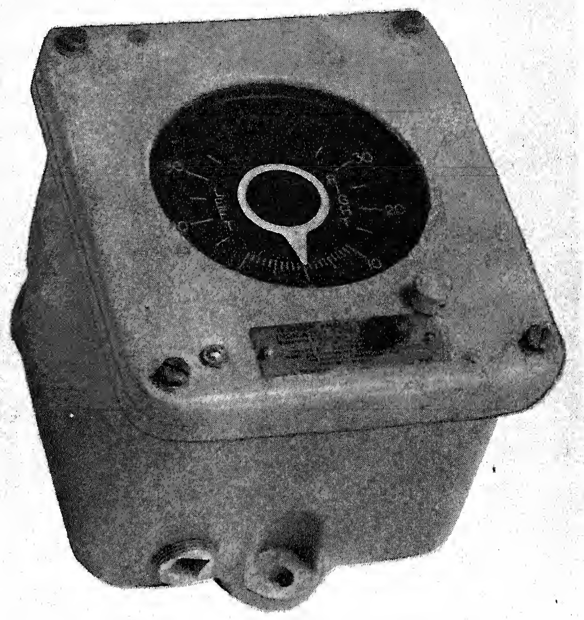
The angular position of the rudder is also transmitted to the receivers associated with circuit N in the units shown in figures 9-9 and 9-10.

Figure 9-13 is a block diagram of the rudder order and rudder angle indicating systems, showing the various units as discussed.

The combination rudder order transmitter-rudder angle indicator, as well as many other indicators and components, is mounted in a steering control console (fig. 9-14) on new construction ships. The console contains much of the information and controls required for a helmsman.



7.129
Figure 9-11.— Rudder angle transmitter.

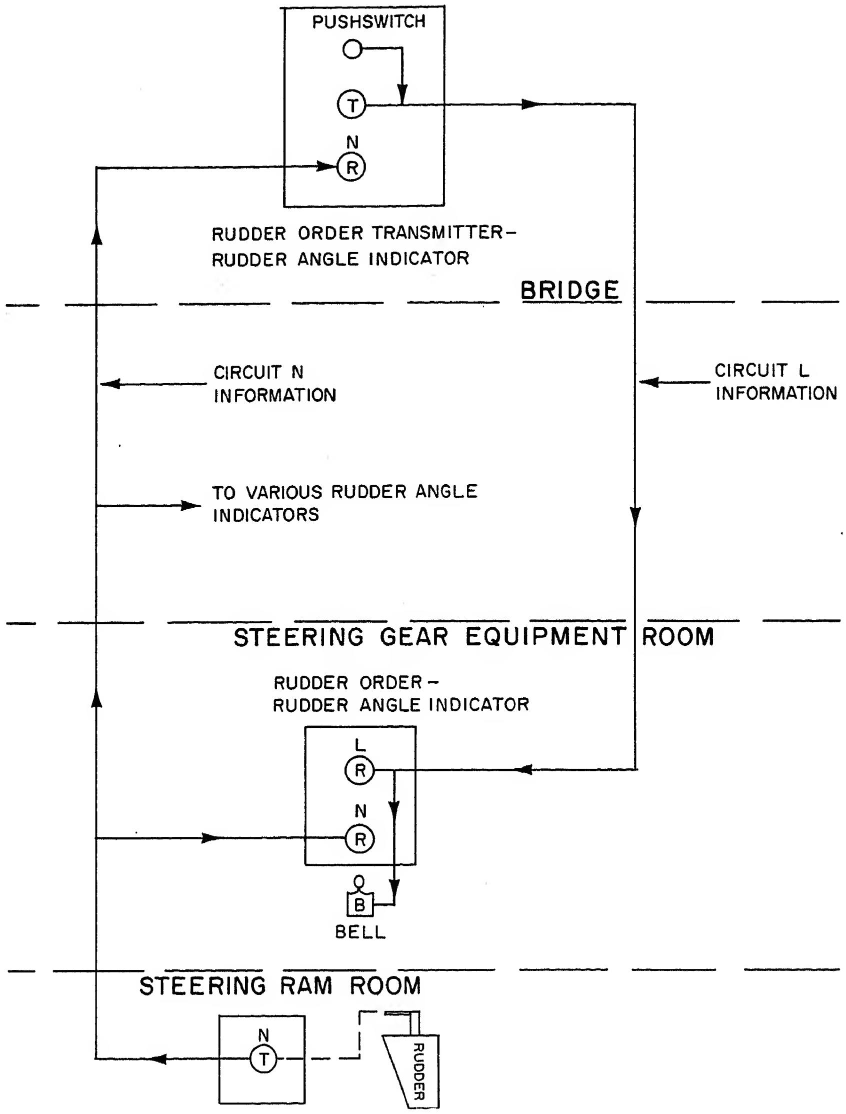


7.126.6
Figure 9-12.—Rudder angle indicator (circuit N).

PROPELLER REVOLUTION INDICATOR SYSTEM

The propeller revolution indicator system (circuit K) indicates instantaneously and continuously the (1) revolutions per minute, (2) direction of rotation, and (3) total revolutions of the individual propeller shafts. The information is indicated in the enginerooms, pilothouse, and other required locations.

The propeller revolution indicator system usually consists of two different types of equipment: (1) synchro-type equipment and (2) magneto-voltmeter type equipment. The synchro-type equipment is installed in large combatant ships and in many newly constructed small ships. The magneto-voltmeter type equipment is less complicated and is installed in small ships.



27.3

Figure 9-13.—Block diagram of basic rudder order-rudder angle indicating system.

SYNCHRO-TYPE EQUIPMENT

A representative synchro-type propeller revolution indicator system installed aboard a DDG as illustrated by the block diagram in figure 9-15. The system consists of two transmitters, two indicator-transmitters, and four indicators. The transmitters are driven by the main engines and are electrically connected to indicator-transmitters at their respective throttle stations. Indicators, such as those in figure 9-16, are a installed on the gage boards in both engineroo and in the pilothouses. Each indicator ha backing signal lamp which, when lighted, deno astern rotation of the propeller shaft.

A synchro signal representing and proportio to the rotary motions of the propeller sl is transmitted by the transmitter (fig. 9-1 to the associated indicator-transmitter (9-16B), which continuously indicates the t

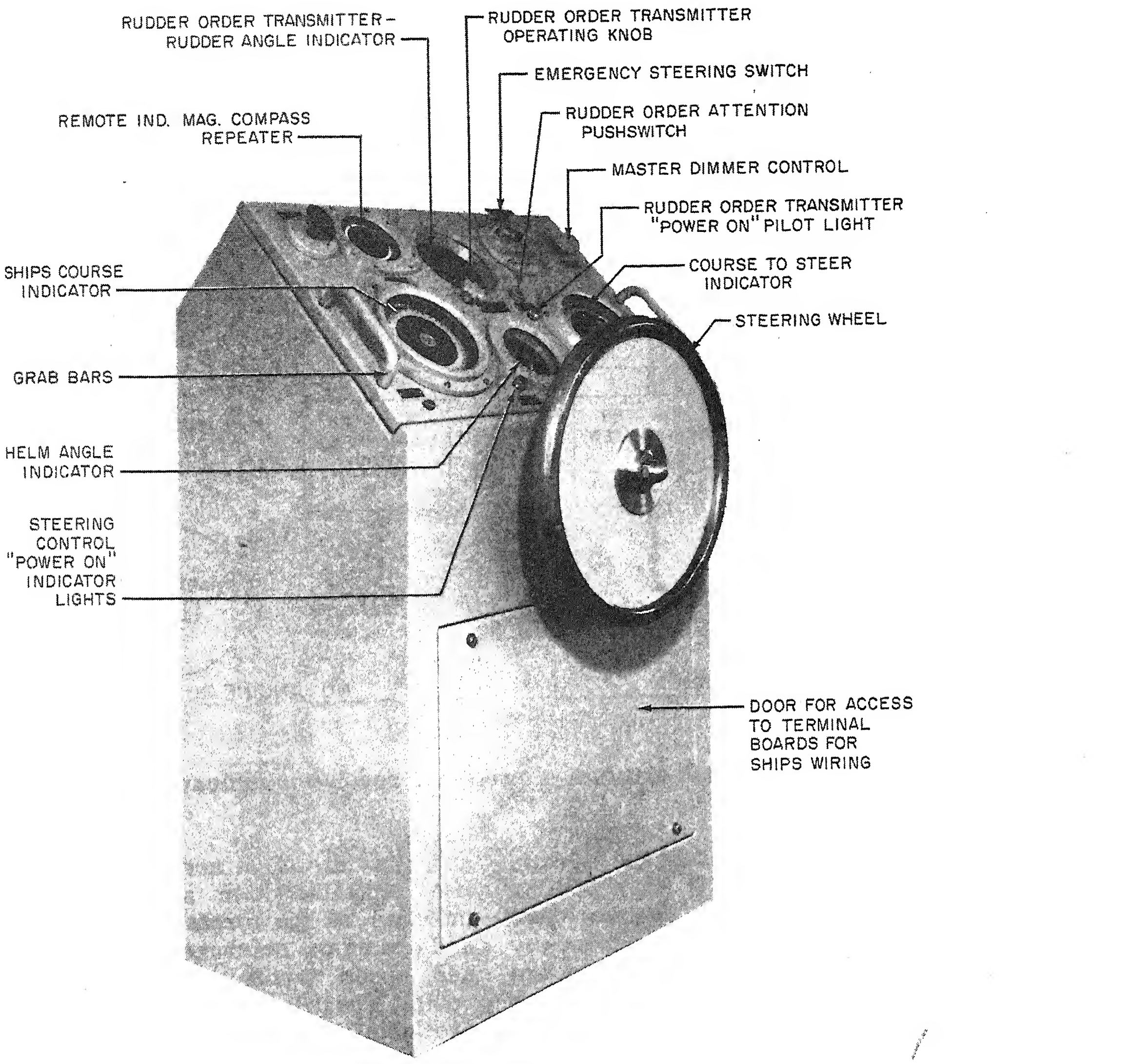


Figure 9-14.—Steering control console.

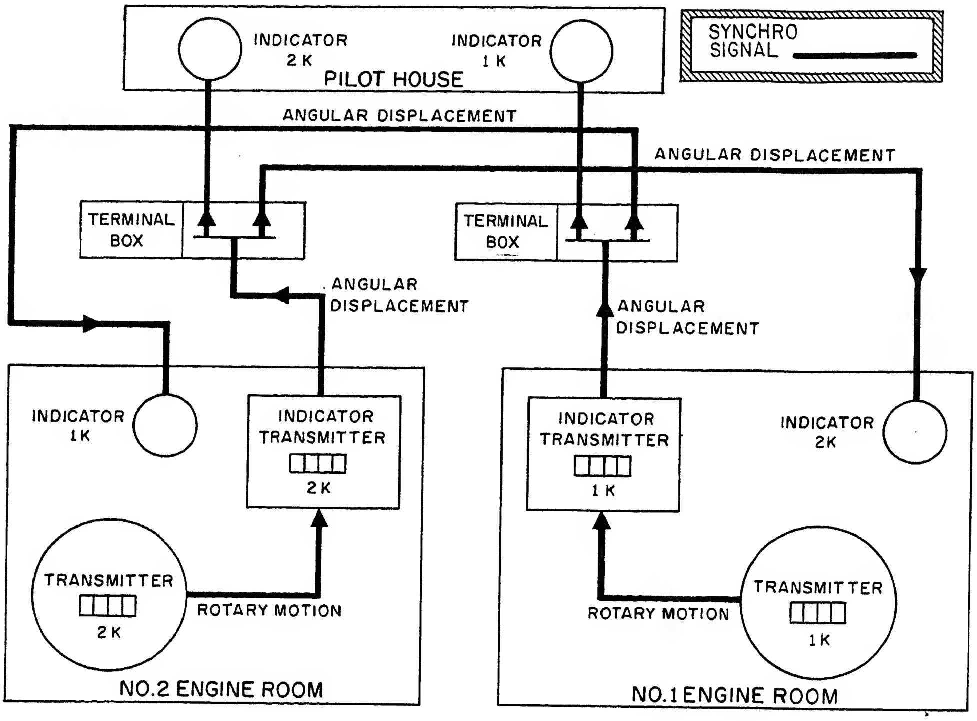
revolutions of the propeller shaft on a counter and converts the received synchro signal into an angular indication of RPM. The RPM reading is also transmitted to indicators via a synchro transmitter contained within the indicator-transmitter.

The indicator (fig. 9-16C), repeats the rpm reading received from the associated indicator-transmitter. The entire system operates on the ship's single-phase, 115-volt, 60-hertz power supply.

MAGNETO-VOLTMETER TYPE

The magneto-voltmeter propeller revolution indicating equipment consists of a magneto-type transmitter geared to each propeller shaft and electrically connected to remotely located indicators which consist of a voltmeter calibrated in revolutions per minute.

The magneto is a permanent magnet type d.c. generator which is driven at a speed proportional to that of the propeller shaft.



27.338

Figure 9-15.—Block diagram of propeller revolution indicator system.

The indicators receive this voltage and indicate on the voltmeter scale the rpm of the propeller shaft. A total revolutions counter registers the total number of propeller revolutions locally at the magneto transmitter unit and a synchro transmitter transmits these revolutions to a synchro receiver which drives the associated total revolutions counter in the remote indicator.

WIND DIRECTION AND SPEED INDICATOR SYSTEM

The wind direction (circuit HD) and speed (circuit HE) indicator system, indicates instantaneously and continuously the (1) wind direction in degrees relative to the ship's heading, and (2) wind speed in knots relative to the ship.

The type-B wind direction and speed indicator system consists of a wind direction and speed detector, wind direction and speed transmitter, and wind direction and speed indicator. Usually two wind direction and speed detectors are mounted on the foremast, one on the port side and one on the starboard side. The wind direction and speed transmitter is installed in the IC room. The wind direction and speed indicators are installed in various spaces as required by the type of ship.

WIND DIRECTION AND SPEED DETECTOR

The wind direction and speed detector (fig. 9-17) consists of a thin-gage Monel metal housing formed into a streamlined wind vane with a relatively large tail surface mounted on a vertical support assembly. The rotor assembly, attached to the head of the vane is held directly into the wind by the vane assembly and converts the wind speed into rotary motion. The speed of rotation of the rotor assembly is proportional to the velocity of the wind striking the rotor blades.

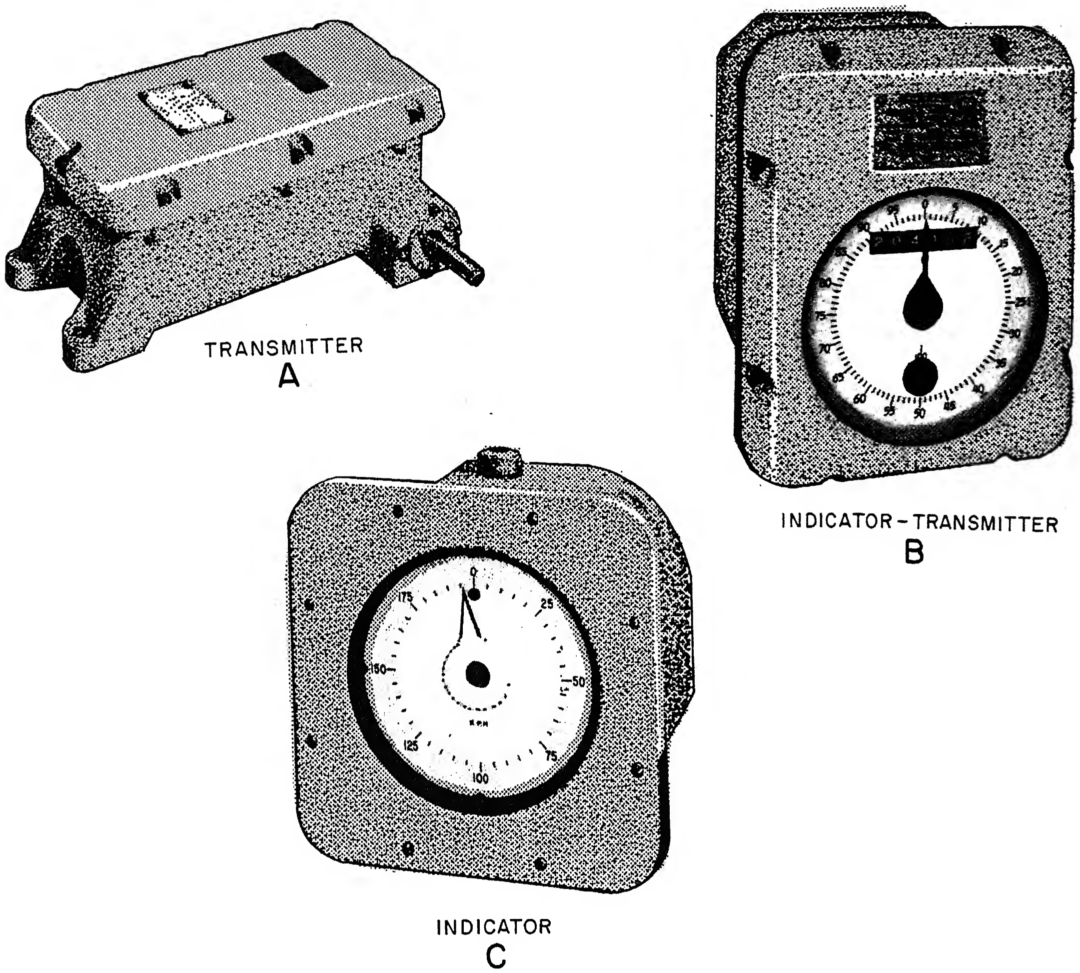


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Figure 9-16.—Propeller revolution indicating equipment.

The direction synchro transmitter, mounted in the vertical support assembly, is directly coupled to the vane so that when the wind positions the vane, the synchro transmitter rotor is displaced the same angular amount. The angular positions are transmitted electrically to a synchro control transformer in the wind direction subassembly of the transmitter (fig. 9-18). Because wind directions are indicated in relative bearings, the direction synchro transmitter in the detector is set to transmit zero when the rotor assembly of the detector unit points to the bow of the ship.

The speed synchro transmitter, mounted in the head of the vane, is coupled through gears to the rotor assembly. The reduced rotary motions are transmitted electrically to a synchro receiver in the wind speed subassembly of the transmitter unit (fig. 9-18).

The mounting and the vertical support assemblies of the wind direction and speed detector are

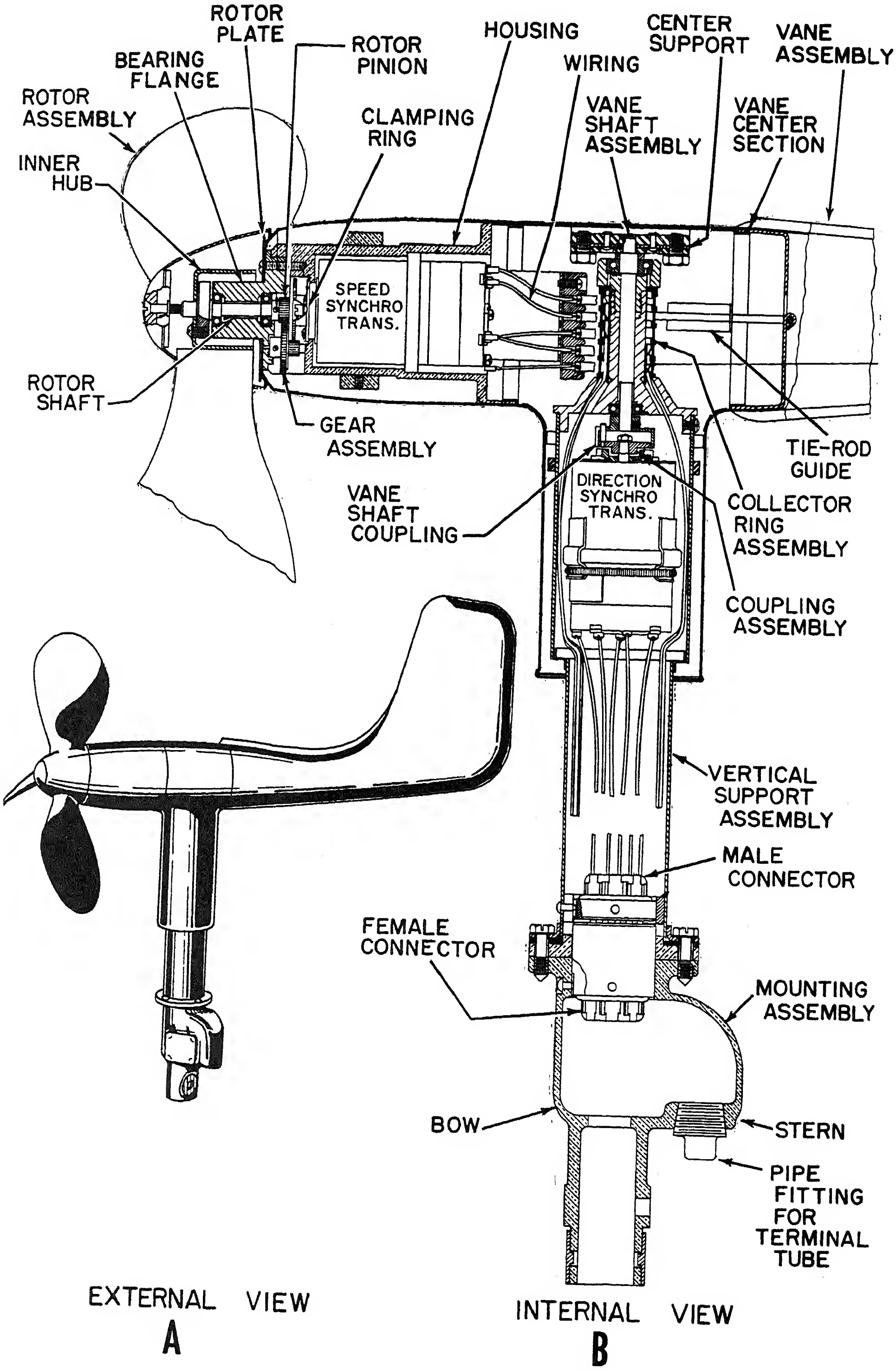

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Figure 9-17.—Wind direction and speed detector.

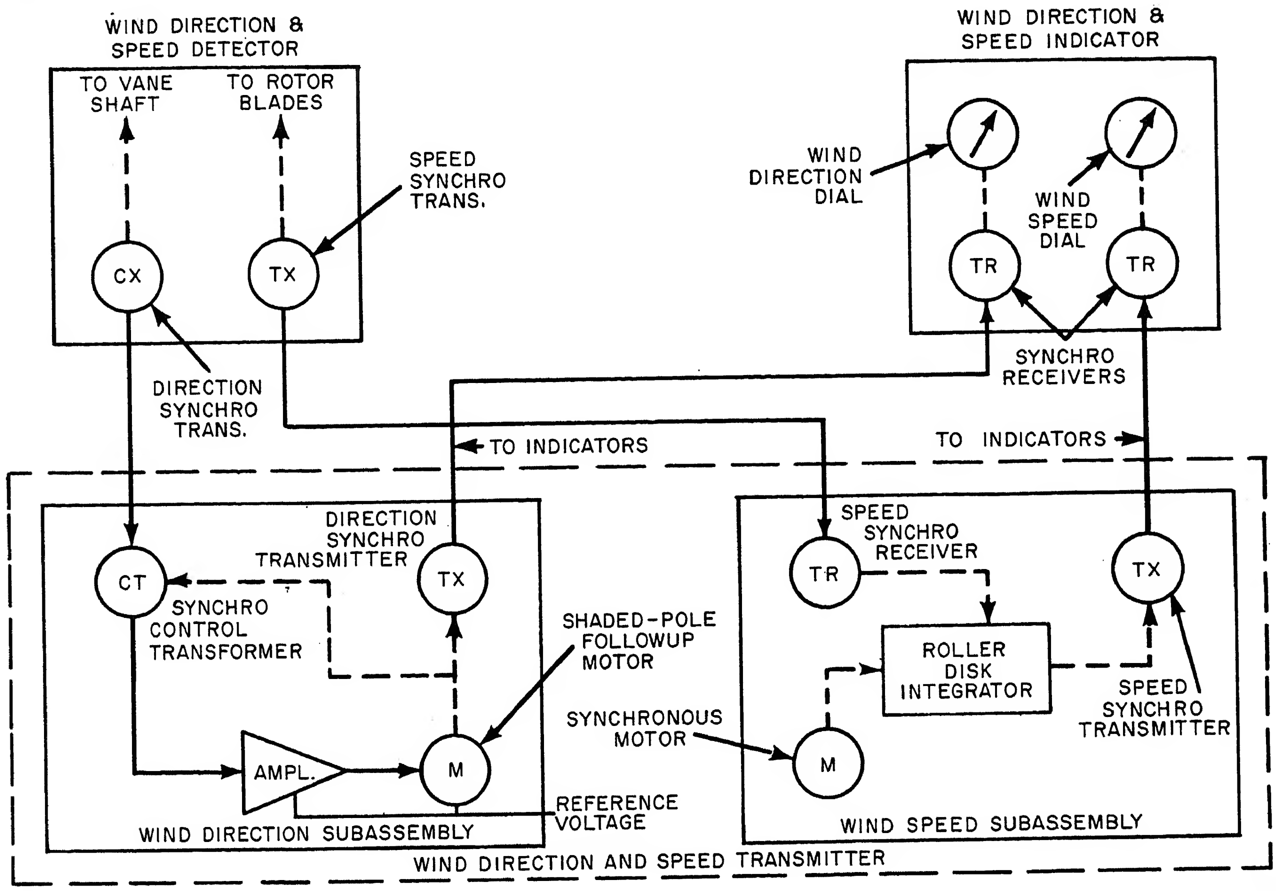

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Figure 9-18.—Block diagram of type-B wind direction and speed indicator system.

provided with flanges for bolting the two sections together.

WIND DIRECTION AND SPEED TRANSMITTER

The wind direction and speed transmitter (fig. 9-18) consists of a wind direction subassembly and a wind speed subassembly mounted on individual baseplates to form a complete unit enclosed in a metal case designed for bulkhead mounting.

Wind Direction Subassembly

The wind direction subassembly is essentially a servo unit comprised of a synchro control transformer, followup amplifier, followup motor, and synchro transmitter.

Please refer to figure 9-18 as we continue our discussion.

When the rotor of the wind direction synchro (CX) located in the wind speed and direction detector, and the rotor of the synchro control transformer (CT), located in the wind direction subassembly, are in correspondence, the output voltage from the synchro control transformer will be zero. When a change in wind direction causes the vane of the wind speed and direction detector to change its position, the direction synchro transmitter and the synchro control transformer rotors will no longer be in correspondence and a voltage is induced in the rotor of the synchro control transformer. The output voltage from the rotor of the synchro control transformer is either in phase or 180° out of phase with the source (reference) voltage, depending on the direction in which the vane has turned. Thus, the phase of the output of the control transformer reverses with respect to the reference voltage as the direction of displacement reverses. The magnitude of the output voltage from the synchro control trans-

former represents the amount by which the shafts of the synchro control transformer and the direction synchro transmitter are out of correspondence. Thus, the direction in which the transmitter shaft is turned determines the phase of the output voltage from the synchro control transformer with respect to the reference voltage, and the amount of displacement determines the magnitude of the output voltage from the synchro control transformer.

The synchro control transformer voltage, caused by the angular displacement, is amplified and fed to the followup motor which drives the synchro transmitter and control transformer through gears into correspondence with the synchro transmitter in the vane. The direction in which the followup motor drives is determined by the phase of the output voltage from the synchro control transformer; the speed at which the followup motor drives is determined by the magnitude of the output voltage from the synchro control transformer. The synchro transmitter located in the wind direction subassembly transmits an angular displacement representing wind direction to the synchro receivers in the remotel located indicators.

Wind Speed Subassembly

The wind speed subassembly (fig. 9-19) utilize a friction disk and roller integrator to conve the rotary motion produced by wind velocit to an angular quantity that may be displaye on a dial. The subassembly receives the rotar motion from the speed synchro transmitter c the detector. The rotary motion, which represent wind velocity, is converted into an angula displacement by the friction disk and rolle integrator assembly. The mechanical output o the integrator positions the rotor of the synchr transmitter which transmits an angular displacement signal representing wind velocity to th various indicators throughout the ship.

WIND SPEED AND DIRECTION INDICATOR

The wind direction and speed indicator (fig. 9-20) is a dual unit consisting of a wind directio

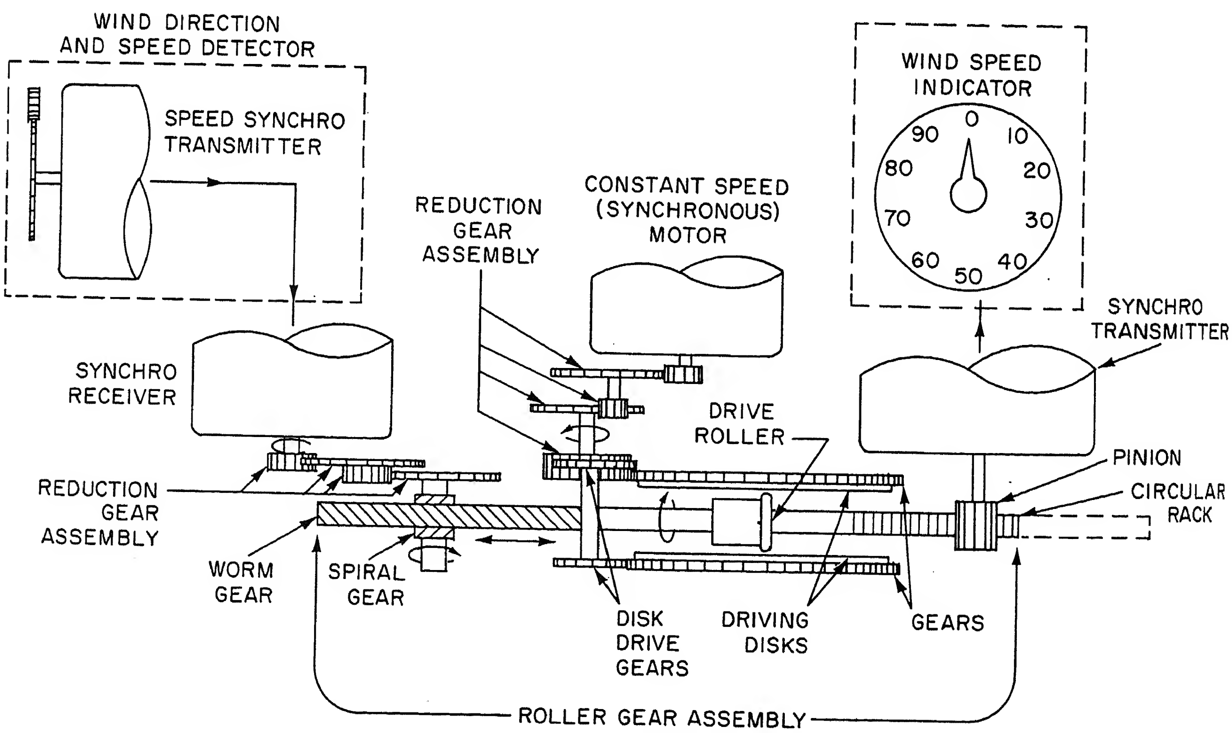

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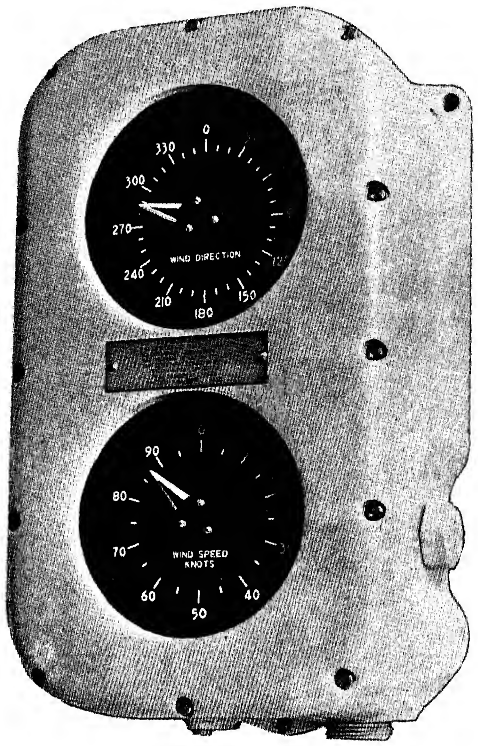
Figure 9-19.—Wind speed subassembly.



7.148
Figure 9-20.—Wind direction and speed indicator.

subassembly and a wind speed subassembly. The two subassemblies are identical except for the dials. Each consists of a synchro receiver which indicates on a fixed dial by means of a revolving pointer attached directly to its shaft. The subassemblies are mounted on individual baseplates and enclosed in a metal housing to form a complete wind direction and speed indicator unit.

SAFETY

The maintenance of the wind speed and direction indicating system, as well as other equipment under the cognizance of E division, requires that personnel work aloft at one time or another. The regulations for men working aloft contained in Navy Safety Precautions For Forces Afloat, OPNAV Instruction 5100.19, and in ship's instructions, must be followed for these operations. Personnel who are to work aloft should be thoroughly familiar with all regulations and safety precautions concerned.

UNDERWATER LOG AND DUMMY LOG SYSTEMS

The underwater log system (circuit Y) measures and indicates the speed of the ship through water and the distance traveled through the water. It transmits these indications to the various speed indicators, distance indicators, and weapons and navigational systems, as required.

The dummy log system (circuit 4Y) produces simulated speed and distance signals for the various ship's systems that require either ship's speed or distance inputs. The system serves two purposes—(1) to simulate ship's movement through the water in order to train personnel and align equipment and (2) to serve as a backup for the underwater log system. The dummy log may be used to supply an estimated speed and distance signal to ship's systems in case the underwater log system becomes inoperable.

In actual practice aboard ship, circuits Y and 4Y are usually tied together by a switching arrangement that permits information pertaining to the ship's speed and distance from either source to be fed throughout the ship to a common set of indicators and equipment.

UNDERWATER LOG SYSTEM

The majority of all current underwater log systems employ the electromagnetic principle to sense the ship's speed through the water. Several different configurations employing this principle of operation have been produced by various manufacturers for the Navy.

Electromagnetic Principle

The electromagnetic principle used in the underwater log system is the same basic principle by which a generator produces a voltage. If a conductor is moved through a magnetic field, a voltage will be induced in the conductor. The magnitude of the induced voltage will vary with the number of active conductors moving through the magnetic field, the strength of the magnetic field, and the speed at which the conductor is moved through the magnetic field. An increase in the number of conductors, the strength of the magnetic field, or the speed of the conductor through the field will result in an increase in induced voltage.

The electromagnetic underwater log functions by placing a magnetic field in seawater. Seawater conducts electricity very well and is used as the conductor. When the ship is not moving through the water, there is no relative motion between the magnetic field and the conductor; therefore, no voltage is induced in the conductor (seawater). As the ship begins to move, relative motion takes place and a voltage is induced in the seawater. An increase in the ship's speed increases the induced voltage directly proportional to the increase in ship's speed. By comparing the induced voltage to a known voltage, an accurate determination of the ship's speed can be made.

Sea Valve and Rodmeter Assemblies

Mounted in the hull of the ship, the sea valve and packing assembly (fig. 9-21 and 9-22) provide a watertight support for the rodmeter, enabling the rodmeter to be retracted or extended through the open sea valve. The sea valve, when closed also seals the hull when the rodmeter is retracted.

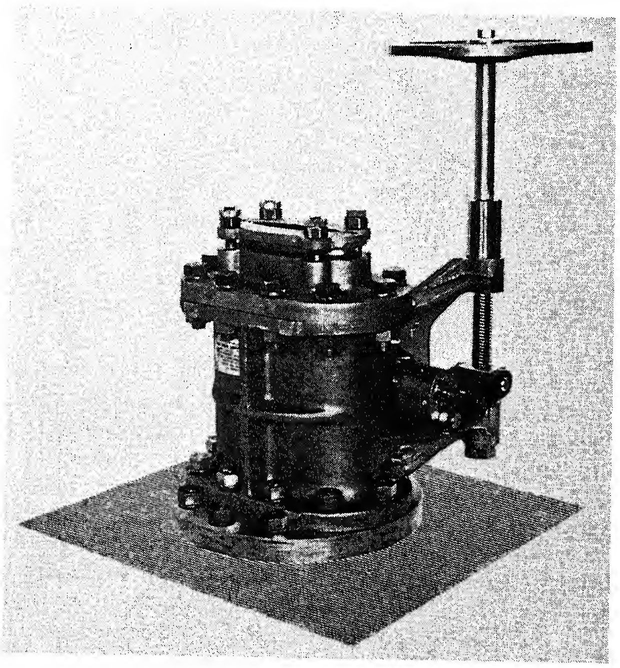


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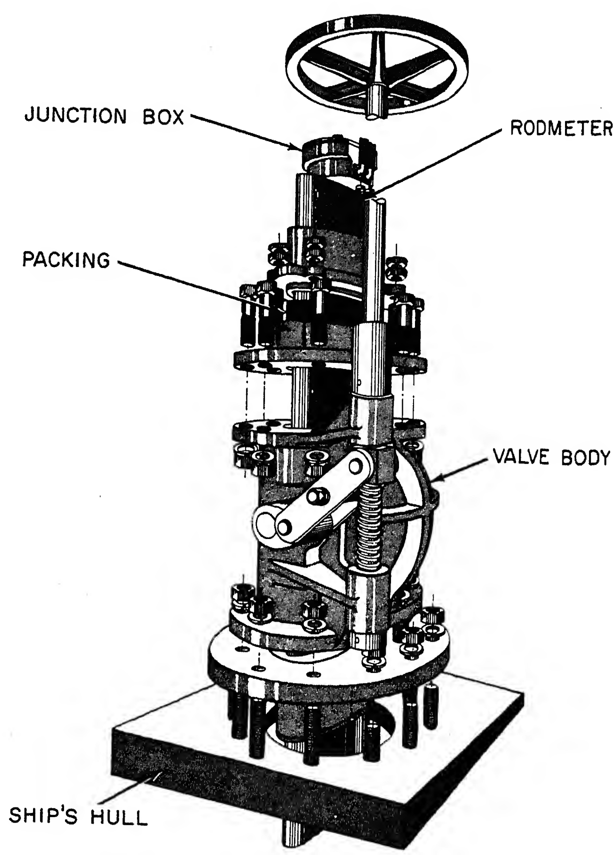
Figure 9-21.—Sea valve.

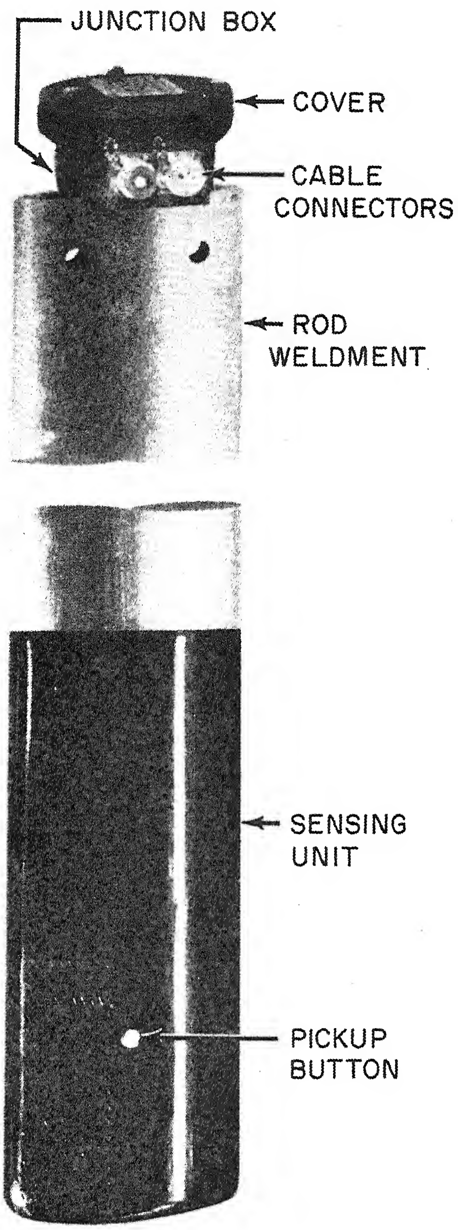


140.159
Figure 9-22.—Exploded view of the sea valve and packing assembly with rodmeter installed.

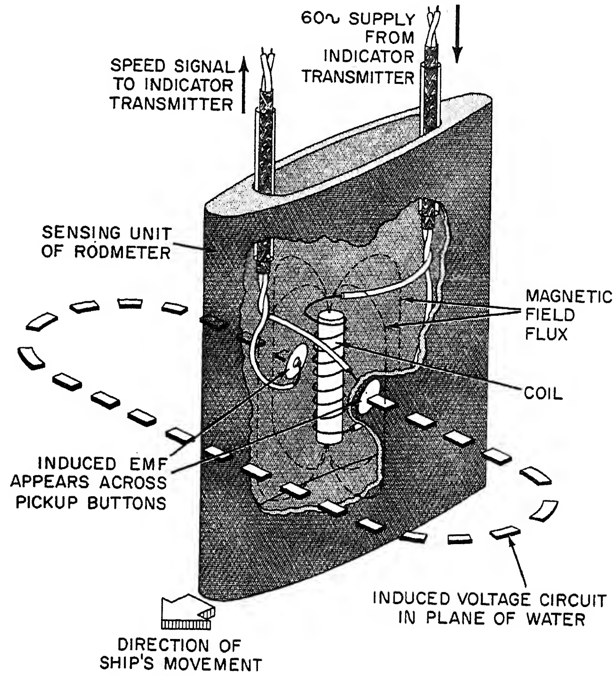
The rodmeter (fig. 9-23) is made of corrosion-resistant Monel metal and is available in different lengths. The main components of the rodmeter are the rod weldment, the junction box, and the sensing unit.

The rod weldment makes up most of the length of the rodmeter. It is a hydrofoil cross section, nickel-copper, watertight tube. The sensing unit is cemented to the lower end of the rod weldment, and the junction box is bolted to the upper end. Two shielded electrical cables connected to the sensing unit pass through the rod weldment and terminate in the cable connectors.

The sensing unit (fig. 9-24) is a plastic molding (boot) made of an epoxy resin mixed with glass fiber. In it are imbedded a coil and two Monel metal buttons.



27.272
Figure 9-23. — Rodmeter.



27.273
Figure 9-24. — Cutaway view of sensing unit.

The coil of the sensing unit is excited with a 60-hertz a.c. voltage, thus creating a magnetic field in the seawater around the rodmeter sensing unit.

As the ship and magnetic field move, the water on both sides of the rodmeter is cut by lines of flux, and a voltage proportional to the velocity of the water is generated on both sides of the rodmeter. The pickup buttons located on each side of the rodmeter make contact with the water and pick up the voltage being generated in the water. This voltage (proportional to the ship's speed through the water) is applied to the indicator-transmitter (discussed later) where the actual ship's speed and distance are calculated.

Fixed Rodmeter

The fixed rodmeter is installed on nuclear submarines and new construction surface craft. It replaces the sea valve and rodmeter assemblies discussed above. As shown in figure 9-25, the rodmeter is mounted through the hull of the ship with the sensing element exterior to the hull and the electrical connection inside the ship. The sensing unit of the rodmeter is basically the same as that of the previously discussed rodmeter. The major advantage of the fixed rodmeter installation is the increased watertight integrity of the hull.

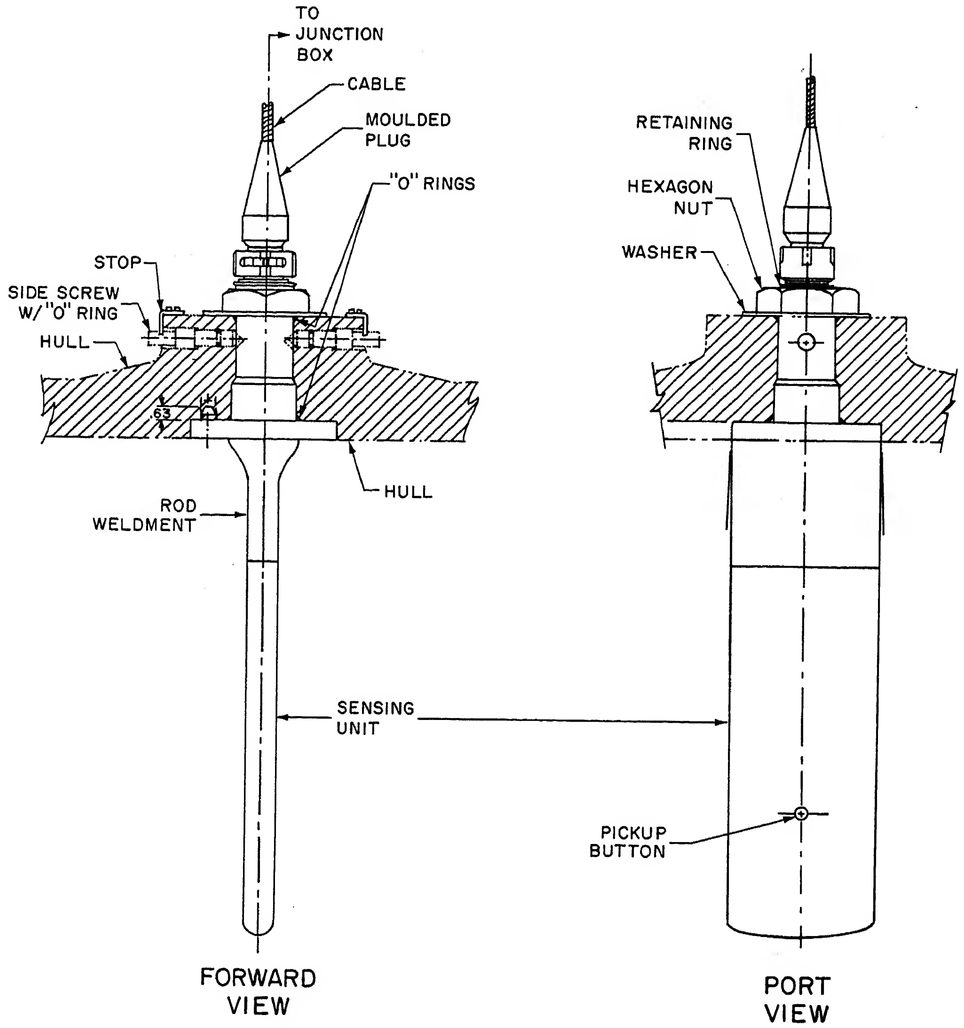


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Figure 9-25.—Fixed rodmeter.

NOTE: Seawater cools the rodmeter and prevents the sensing element from overheating when the system is operating. To prevent possible damage to the sensing element of the rodmeter the underwater log equipment should never be energized unless the sensing element is emersed in water.

Indicator-Transmitter

The indicator-transmitter contains all the electrical and mechanical components necessary to measure the voltage from the rodmeter and to convert it into ship's speed and distance signals.

Two underwater log systems (the Litton Indicator-Transmitter and the Chesapeake Indicator-Transmitter) will be discussed below. The rodmeters of both systems are interchangeable. The type shown in either figure 9-23 or 9-25 may be used. The construction of the indicator-transmitters is the most distinctive difference between the two systems.

LITTON INDICATOR-TRANSMITTER.—The Litton indicator-transmitter (fig. 9-26) is the

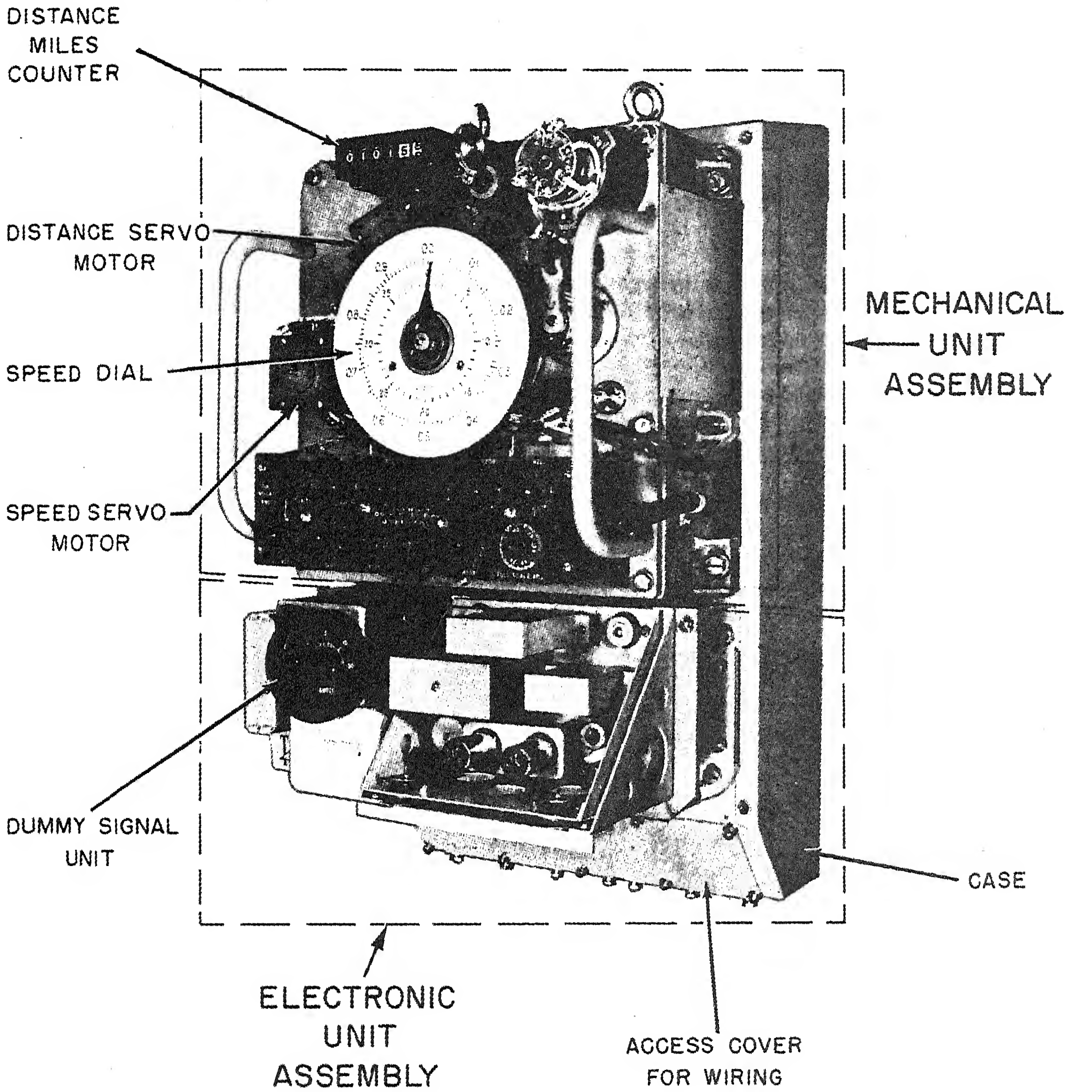

Figure 9-26.—Litton indicator-transmitter (cover removed).

older in design of the two units. It has been installed in Navy ships for approximately 20 years.

The Litton underwater log system is comprised of the components shown in figure 9-27. The system functions as follows: The rodmeter produces an a.c. signal voltage proportional to the ship's speed. This signal is amplified and fed to the speed servomotor, which drives the speed synchro transmitter, the dual-pointer dial, and the integrator. The integrator converts the input from the speed servo into a distance-traveled output which drives a synchro-transmitter and a 6-drum counter to display distance traveled in nautical miles. A dummy signal circuit (not shown) performs no function in normal equipment operation but provides simulated signals that can be used in checking the functioning of the system.

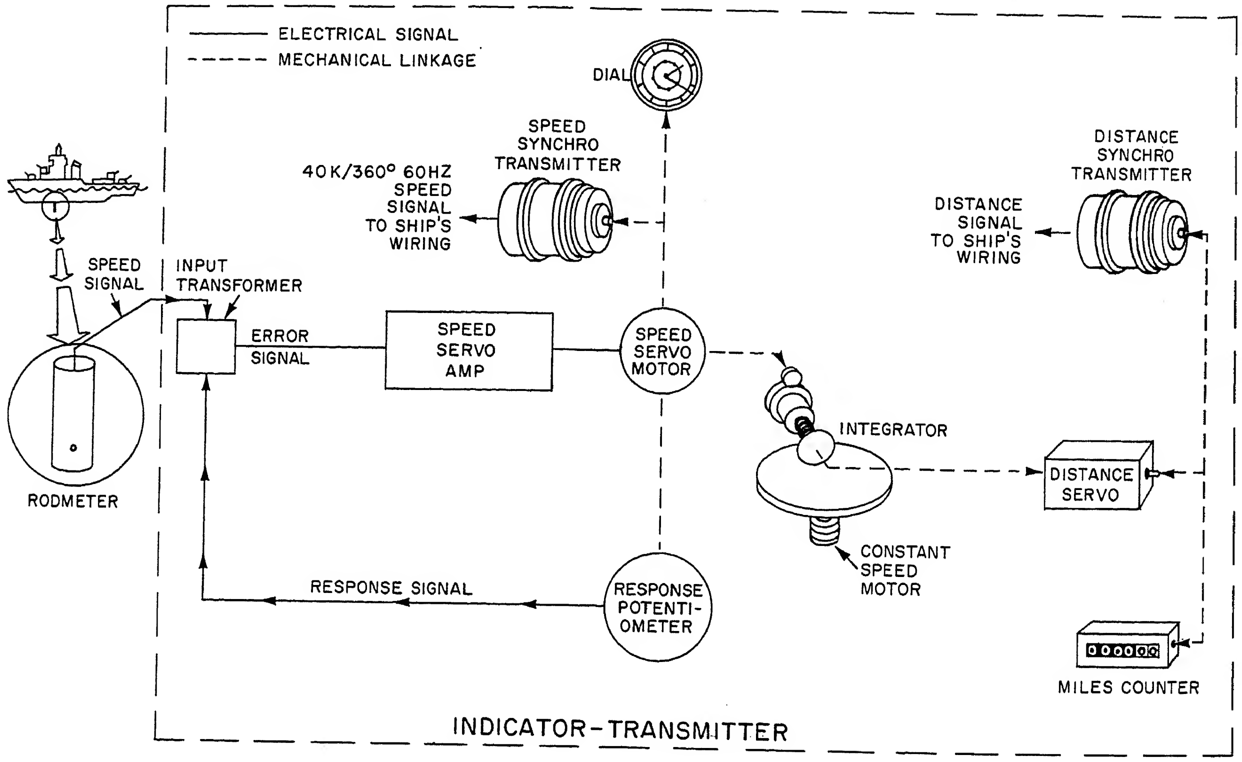

Figure 9-27.—Block diagram of—Litton Underwater Log System. 27.27'

Refer again to figure 9-27. The input transformer functions as an error detector. It receives the speed voltage generated by the rodmeter and a response signal which is a measured voltage that represents the present position of the response potentiometer.

When the response potentiometer is properly positioned, the response signal cancels out the speed signal in the input transformer and therefore the error signal (output signal) from the input transformer will be zero. When the speed signal and the response signal are not of the same magnitude, an error signal is produced by the input transformer. The error signal is magnified by the servoamplifier until it is of sufficient magnitude to drive the speed servomotor. The speed servomotor drives the dial, speed synchro transmitters, integrator, and the response potentiometer in accordance with the error signal through gearing until the response signal again equals the speed signal. For any change in speed, an error signal is developed which causes the servomotor to drive the gear train until the signal from the response potentiometer again equals the speed signal.

In this manner, the indicator-transmitter continuously indicates ship's speed on the dial and the speed synchro transmits ship's speed to the various ship's repeaters.

The integrator is used in the indicator-transmitter to change an angular displacement into a rotary motion. The roller is positioned on the disk of the integrator by the speed servomotor. The position of the roller represents ship's speed. The position nearest the center represents zero ship's speed, while a position near the edge represents 40 knots. Depending on ship's speed, the roller of the integrator is driven by the disk at a speed that represents ship's distance traveled. The integrator output is used to drive a miles counter and a synchro transmitter which transmits a corresponding signal to remote receivers. However, because a direct load on the integrator output will likely cause the roller to slip, a distance servo has

been inserted between the integrator and its load. The distance servo is used to drive the counter and distance synchro transmitter. In this way the integrator is mechanically isolated from its load.

The dummy signal circuit (not to be confused with the dummy log system) produces voltage signals which simulate speed outputs from the rodmeter. Such signals can be used to check the performance of the speed and distance servos. The dummy signal circuit provides a simulated speed signal that causes the speed servo to stabilize at any of four dial readings (0, 5, 15, or 30 knots) and permits measurement of the accuracy of distance servo and integrator functioning. The dummy signals are not intended for calibration purposes; they only check the functioning of the equipment, and proper operation of the equipment with dummy signals does not necessarily mean that it will properly measure and indicate ship's speed through the water.

CHESAPEAKE INDICATOR-TRANSMITTER. — The Chesapeake indicator-transmitter (fig. 9-28) uses solid state devices

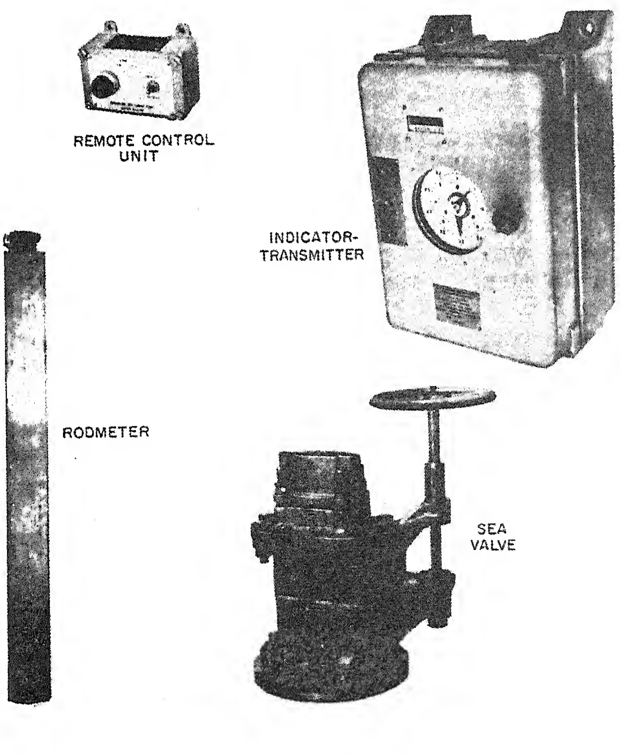

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Figure 9-28.—Major components of the Chesapeake Underwater Log System.

and its circuits reflect changes in the state of the art that took place between the development of the Litton and the development of the Chesapeake. As you can see in figure 9-29, the basic principles of operation in the two are very similar. The principal differences between the two are that the Chesapeake unit: can supply five different synchro speed output signals; has the dummy log system (circuit 4Y) incorporated into its circuitry; uses logic circuits in the speed servoamplifier; and uses a solid state integrator, which also uses logic circuits, instead of the mechanical integrator of the Litton unit.

In operation the speed, response, and error signals are developed inside the Chesapeake unit essentially as described for the Litton unit. The speed servoamplifier contains logic circuits which convert the a.c. error signal into d.c. pulses. The logic circuits are controlled by an oscillator which determines the rate at which the pulses are produced. The polarity of the pulses depends on the polarity of the error signal. Both the pulses and error signal are always of such polarity that the servomotor drives in the direction that will eliminate them. The speed servomotor (a d.c. stepping motor) is stepped by the d.c. pulses. Each pulse from the servoamplifier causes the servomotor to step 1.8° in response to the pulses. As previously stated the rate of pulses from the amplifier, and therefore, the speed at which the servomotor steps, is dependent on the oscillator. The oscillator can produce two different frequencies. The higher of the two frequencies triggers the logic circuits at such a rate that pulses are produced which cause the servomotor to respond to speed changes at a rate of 40 knots per minute. The lower frequency of the oscillator limits the response of the logic circuits, so that the rate at which the pulses are produced will drive the servomotor at a rate of 8 knots per minute.

The slow speed is used to smooth out oscillations of the rodmeter signal which are caused by ship's motion (other than forward motion) or water turbulence. The servomotor drives the response potentiometer, speed dial, and the five synchro speed transmitters, as well as provides a mechanical input for the solid state distance integrator.

Five different speed signals are produced by the speed synchro transmitters — a 60-hertz signal at 40 knots/360° and 100 knots/360° and a 400-hertz signal at 10 knots/360°, 40 knots/360°,

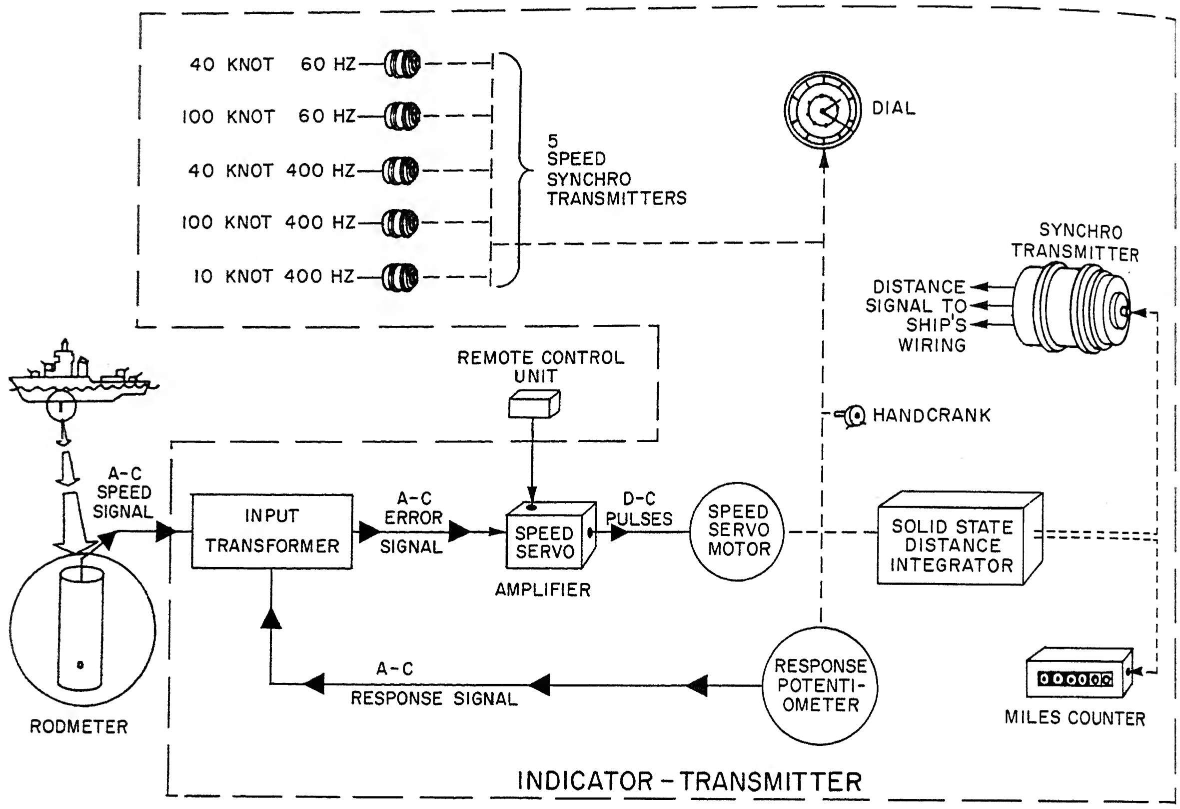

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Figure 9-29.—Block diagram of Chesapeake Underwater Log System.

and 100 knots/360°. The 40-knot/360° 60-hertz output drives the ship's speed repeaters. The other outputs supply speed information to fire control and navigation equipment.

The solid state distance integrator receives a mechanical input from the speed servo. This mechanical input is converted to an electrical signal which represents the ship's speed. The electrical speed signal is measured inside the solid state integrator where pulses are produced at a rate proportional to the magnitude of the speed signal. These pulses are applied to the distance stepmotor, which drives the distance synchro transmitter and miles counter at a rate which corresponds to the distance traveled through water.

When the Chesapeake underwater log system is operating as a dummy log system, the speed input signal from the rodmeter is disconnected from the indicator transmitter. An estimated ship's speed may be set into the indicator-transmitter either manually through the use of the handcrank or through the remote control unit shown in figures 9-28 and 9-29. The indicator-transmitter transmits both the estimated speed and the ship's distance based on the estimated speed to the ship's speed repeaters and equipment.

DUMMY LOG SYSTEM

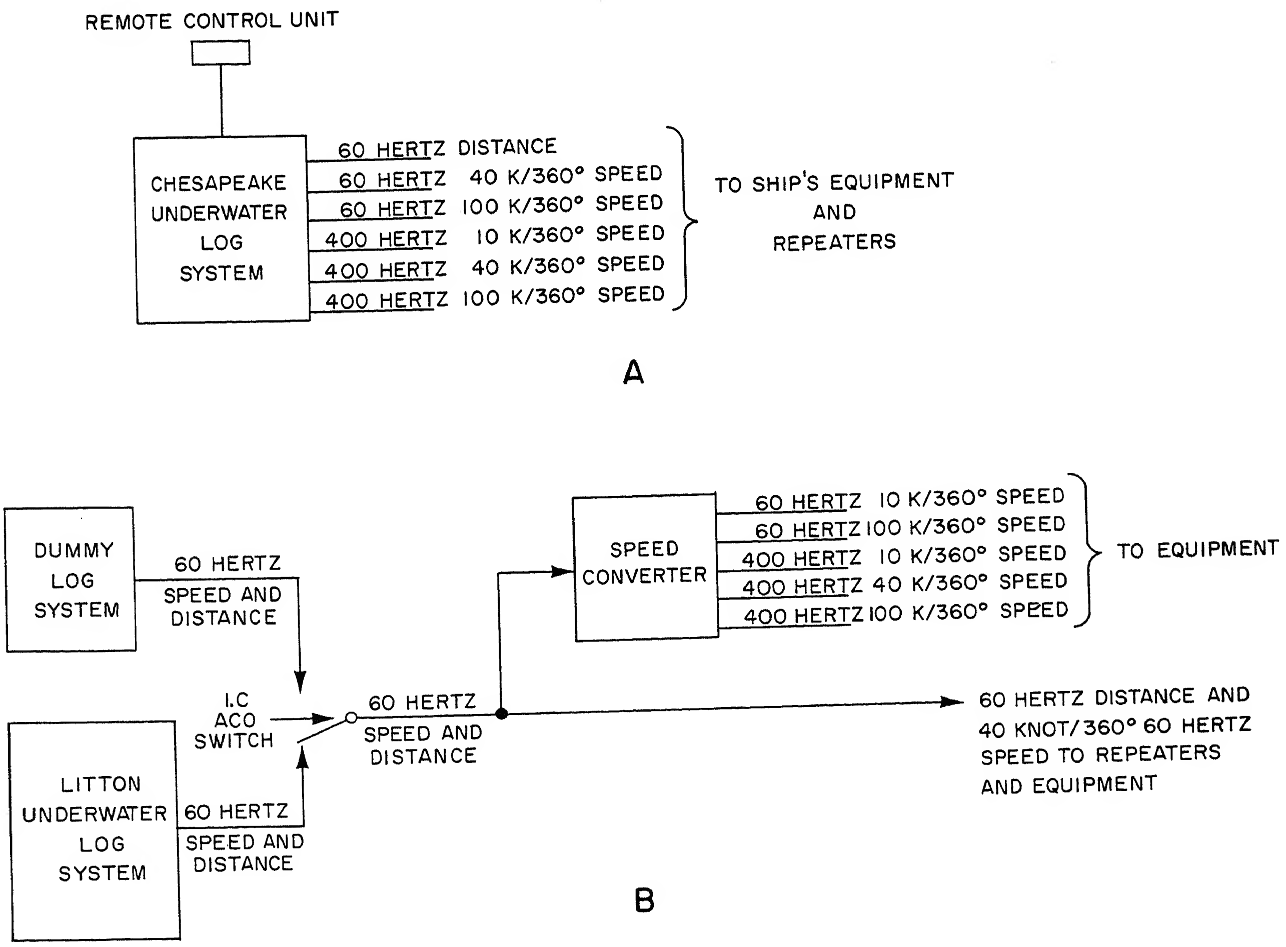
Before the development of the Chesapeake underwater log system, a separate dummy log system was installed aboard ships. The system consists of a speed transmitter and a distance transmitter. The speed transmitter was normally located at the main engineroom control station and was used to set the estimated ship's speed into the system. The distance transmitter received the control signal from the speed transmitter. The distance transmitter then transmitted speed and distance to the ship's repeaters and equipment.

UNDERWATER LOG SPEED CONVERTER

The underwater log speed converter, like the dummy log system, is required on most ships that do not have a Chesapeake underwater log system. All underwater log and dummy log systems prior to the development of the Chesapeake underwater log system contained only one speed transmitter synchro. All those systems transmitted speed as a 40-knot/360° (1 knot graduation for every 9° on dial face), 60-hertz signal. However, newer equipment was developed that required speed information other than 40-knots/360° 60-hertz. The speed converter acts as an interface unit between the newer equipment and the older underwater/dummy log systems. The speed converter receives a 40-knot/360°, 60-hertz speed signal and, through the use of a servo system and gearing, repositions five synchro transmitters which then transmit 10-knot/360°, 40-knot/360°, 100-knot/360° 400-hertz; 10-knot/360°, 100-knot/360° 60-hertz speed signals to equipment that requires them. Figure 9-30 illustrates the speed converter in the underwater/dummy log system and shows the difference between typical Litton and Chesapeake systems.

DEAD RECKONING SYSTEMS

The dead reckoning systems provide a means of plotting the ship's position graphically on an



27.386

Figure 9-30.—Underwater and Dummy Log Installations: (A) Chesapeake, (B) Litton, including dummy log and speed converter.

appropriate chart, plotting the ship's track, and plotting targets relative to the ship's position. Most dead reckoning systems also indicate the ship's position in latitude and longitude on mechanical dials.

There are several different types of dead reckoning equipment. In this section we shall discuss the Arma system, various NC-2 plotting systems, and the Mk 6 Mod 4B Dead Reckoning Tracer used in conjunction with the Mk 9 Mod 4 Dead Reckoning Indicator Analyzer.

ARMA DEAD RECKONING EQUIPMENT

The Arma dead reckoning equipment (DRE) contains (1) a dead reckoning analyzer and (2) a dead reckoning tracer. A block diagram of the dead reckoning system is illustrated in figure 9-31.

Arma Dead Reckoning Analyzer

The dead reckoning analyzer (DRA) (fig. 9-32) receives the ship's distance input from either the underwater or dummy log system. This input is in the form of a rotary motion, the rate of rotation being directly proportional to ship's speed. The DRA also receives the ship's course input from the ship's gyrocompass. The DRA using the ship's course input, resolves th ship's distance input into rotary E-W and N- distance components. This information is dis played on counters located inside the DRA an is transmitted by the d.c. step transmitters t the Arma dead reckoning tracer.

Arma Dead Reckoning Tracer

The dead reckoning tracer (DRT) (fig. 9-3: consists of (1) a tracking mechanism, (2) chart board that includes the pencil carria assembly, and (3) an auxiliary plotting boar The auxiliary plotting board, which is the gla top of the DRT, is used for plotting ranges a bearings of contacts that are being tracked a for plotting own ship's position. The DRT housed in a metal case designed for horizon mounting on a table or cabinet and is usua located in the combat information center.

The tracking mechanism of the DRT contai the step-by-step receivers and gears that positi the pencil carrier assembly in response to t E-W and N-S distance inputs from the DRA. The are two such receivers and gear trains—t cross screw drive assembly and the lead scr drive assembly. The cross screw and le screw drive assemblies position the pencil carr assembly along the axes shown in figure 9-

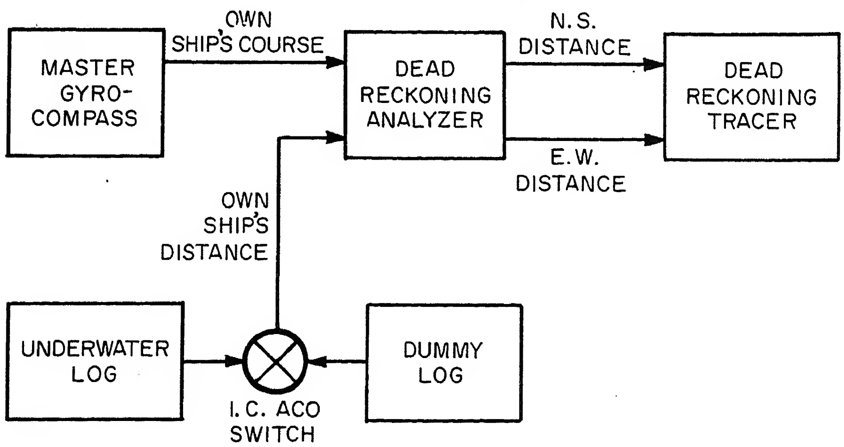


Figure 9-31.—Dead reckoning system, block diagram.

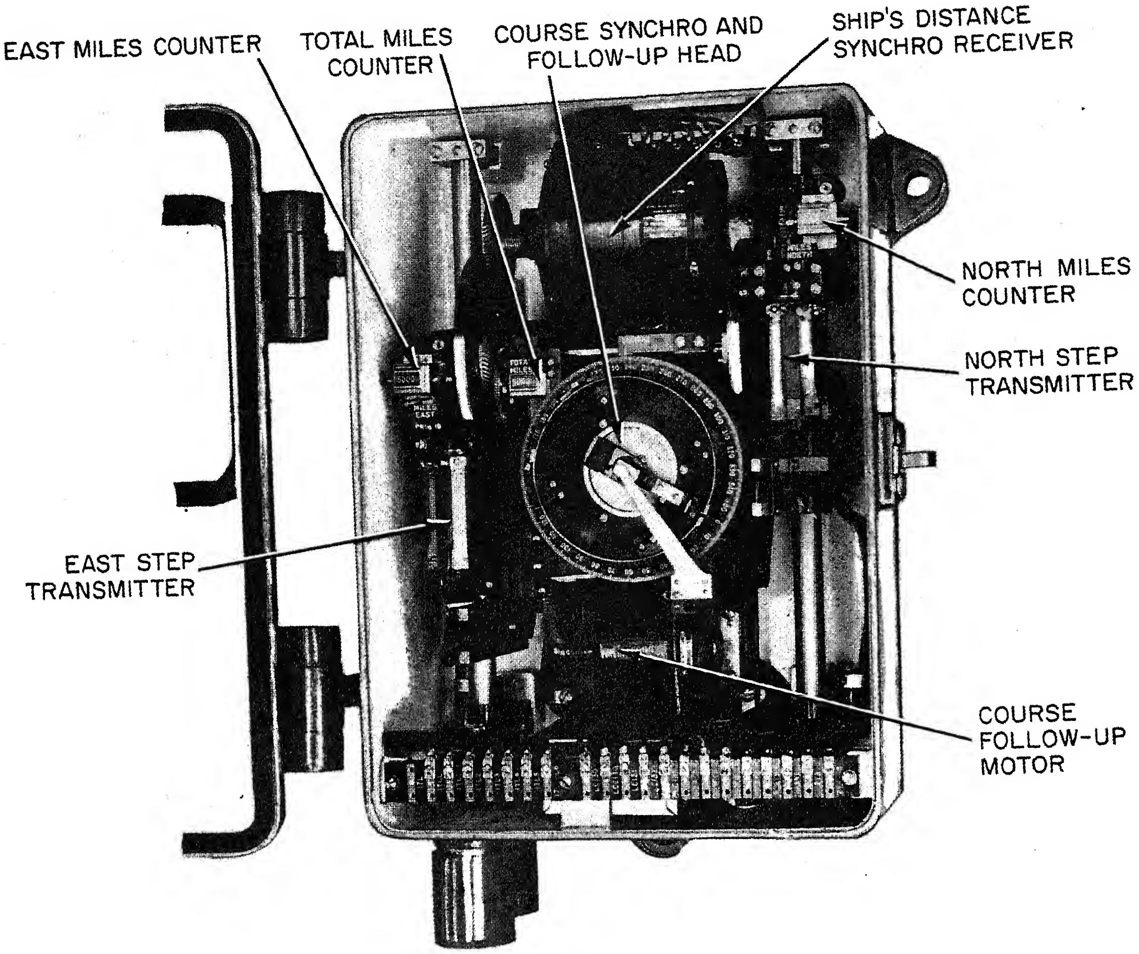


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Figure 9-32.—Arma dead reckoning analyzer.

By means of a switch either axis may be selected to represent a N-S direction. That is, either the lead screw or cross screw drive assemblies may be actuated by the N-S or E-W distance input. Both drive assembly gear trains are adjustable and may be shifted to provide four different tracking scales so that 1 inch of movement by the pencil carriage assembly may represent from 200 yards to 16 miles of ship's movement.

The chart board consists of a recessed plotting surface in the left-hand section of the DRT case below the pencil carriage assembly (fig. 9-33). A pencil, attached to the pencil carriage assembly, automatically traces the movements of the ship on a chart inserted on the plotting surface.

The pencil carrier assembly is illustrated in figure 9-34. The pencil carrier assembly is supported by the pencil carriage assembly and includes the pencil, the pencil magnet, and the range-bearing projector. The pencil magnet is actuated by a clock-driven switch located with the tracer mechanism which energizes

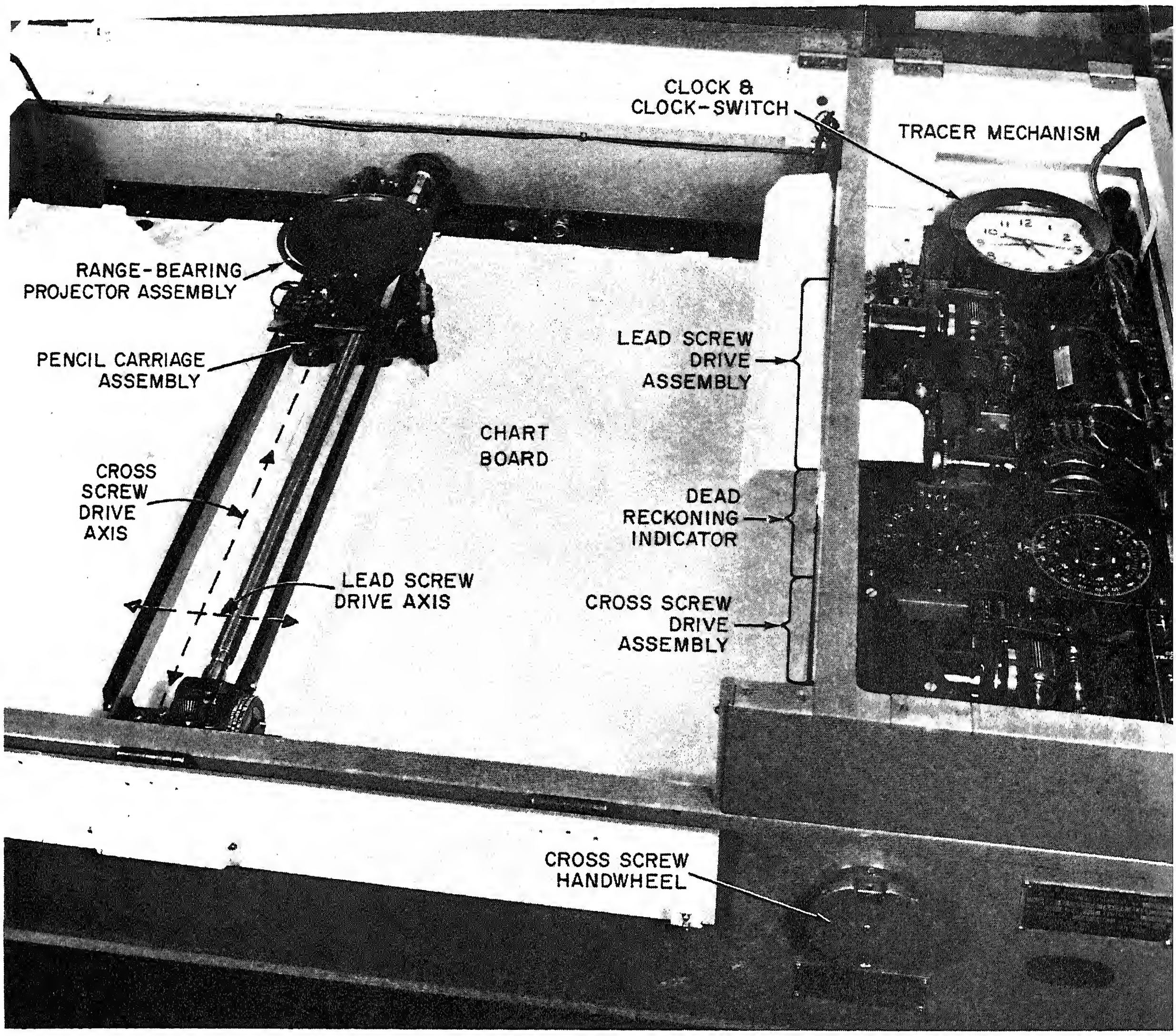

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Figure 9-33.—Arma dead reckoning tracer and dead reckoning indicator.

the pencil-magnet circuit at predetermined intervals. This action causes the magnet to lift the pencil from the chart periodically to omit the trace to facilitate interpreting the plot. The range-bearing projector assembly (plotting light) is mounted on the pencil carrier for use in conjunction with the auxiliary plotting board to indicate the own ship's position at all times. It projects a polar diagram display on the underside of the auxiliary plotting board. This projected polar diagram is used to plot own ship's track, position, and the position of targets relative to the ship.

Dead Reckoning Indicator

The dead reckoning indicator (DRI) (fig. 9-3 is located with the tracking mechanism of t dead reckoning tracer. It consists of a dial u assembly that includes the latitude motor (driv by N-S distance signal from DRA), the longitu motor (driven by E-W distance signal from DR and dials. The latitude and longitude dial asser blies each consist of two concentric dials. T outer latitude and longitude dials are graduat in degrees, and the inner latitude and longitu dials are graduated in minutes.

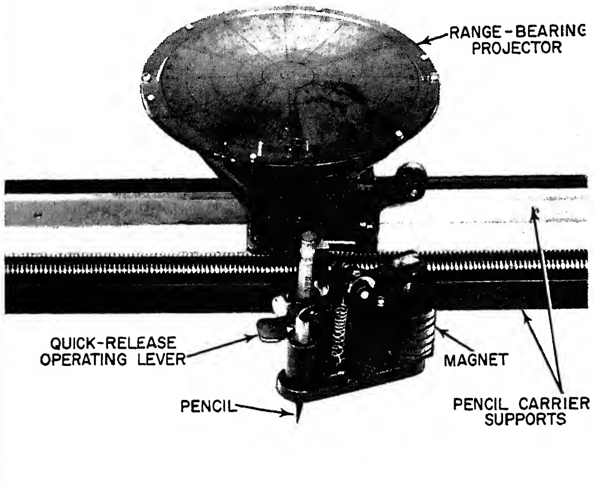

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Figure 9-34.—Pencil carrier and range-bearing projector assembly.

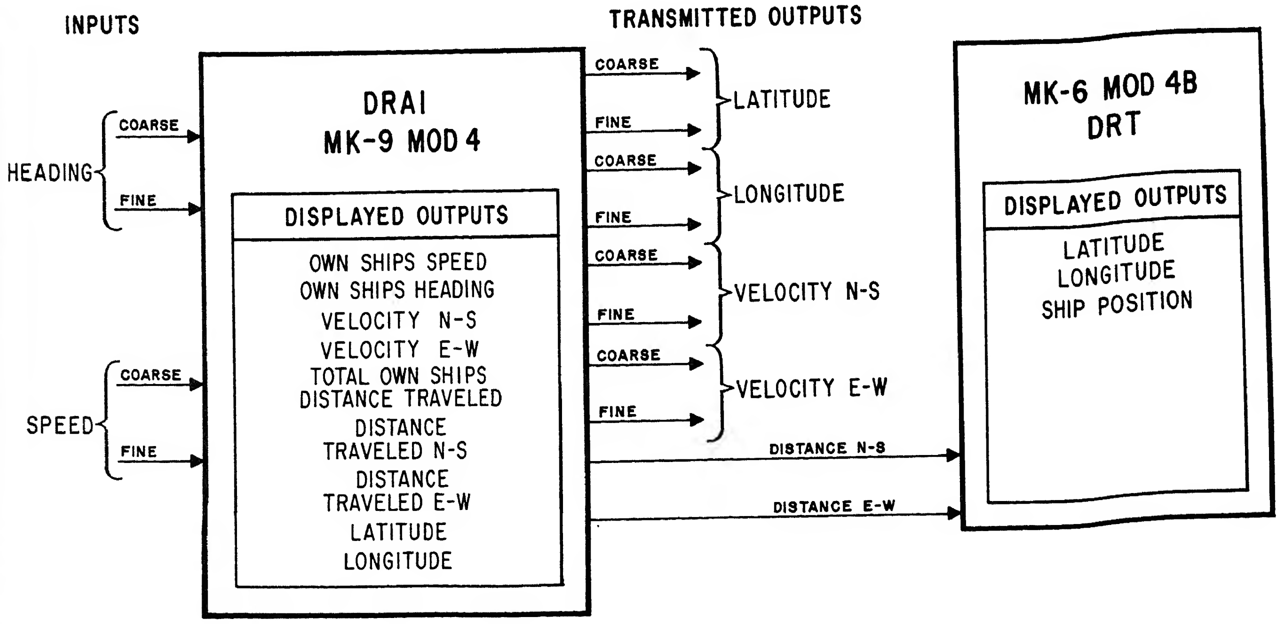
NEW DESIGN DEAD RECKONING EQUIPMENT

One of the Navy's newer dead reckoning equipment systems consist of the Dead Reckoning Analyzer Indicator (DRAI) such as the Mk 9 Mod 4 (DRAI) and the Mk 6 Mod 4B Dead Reckoning Tracer (DRT). Figure 9-35 is a block diagram of this equipment.

Mk 9 Mod 4 DRAI

The Mk 9 Mod 4 DRAI (fig. 9-36) is a hybrid analog/digital device which continuously computes, transmits, and displays principal navigation information. The DRAI accepts synchro information of own ship's speed from the ship's underwater log system and own ship's heading from the ship's gyrocompass system. Information required for dead reckoning is calculated from these signals and displayed on the various dials and counters on the front of the DRAI. Some of the information is electrically transmitted to related shipboard equipment. Figure 9-35 illustrates which information is displayed and transmitted by the Mk 9 Mod 4 DRAI.

The DRAI is used aboard surface ships and submarines. It can drive up to four Mk 6 Mod 4B DRT's simultaneously. When properly maintained, the DRAI is much more accurate than the Arma DRA.



40.56(40D)
Figure 9-35.—Block diagram of the Mk 9 Mod 4 DRAI and Mk 6 Mod 4B DRT.

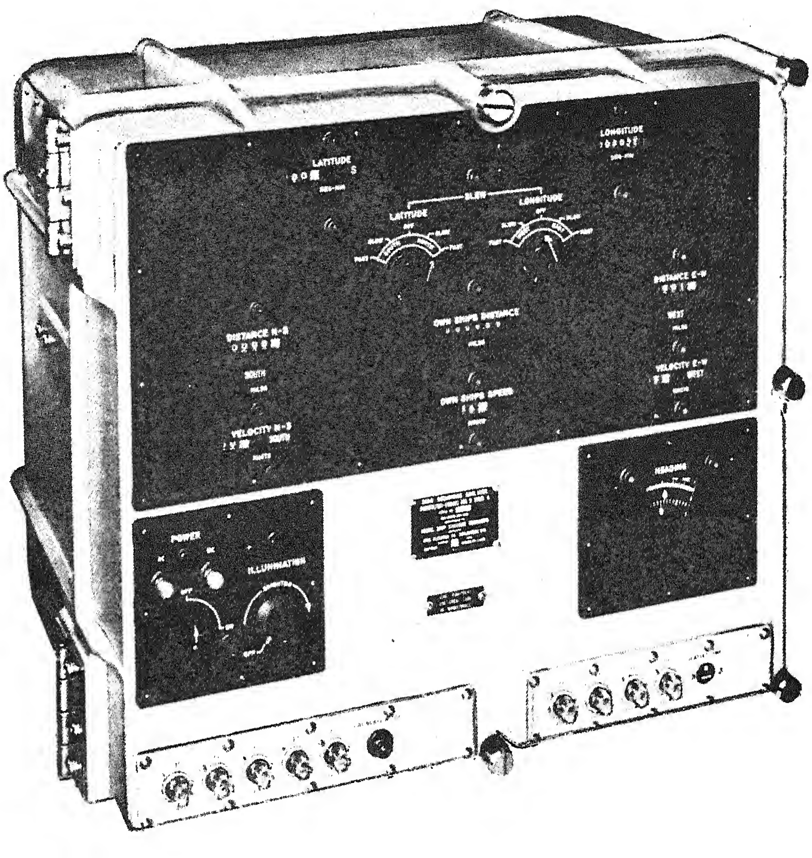


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Figure 9-36.—DRAI Mk 9 Mod 4 dead reckoning analyzer indicator.

Dead Reckoning Tracer Mk 6 Mod 4B

The Mk 6 Mod 4B Dead Reckoning Tracer (DRT) (fig. 9-37) graphically records own ship's dead reckoning track and computes and displays own ship's latitude and longitude on counters.

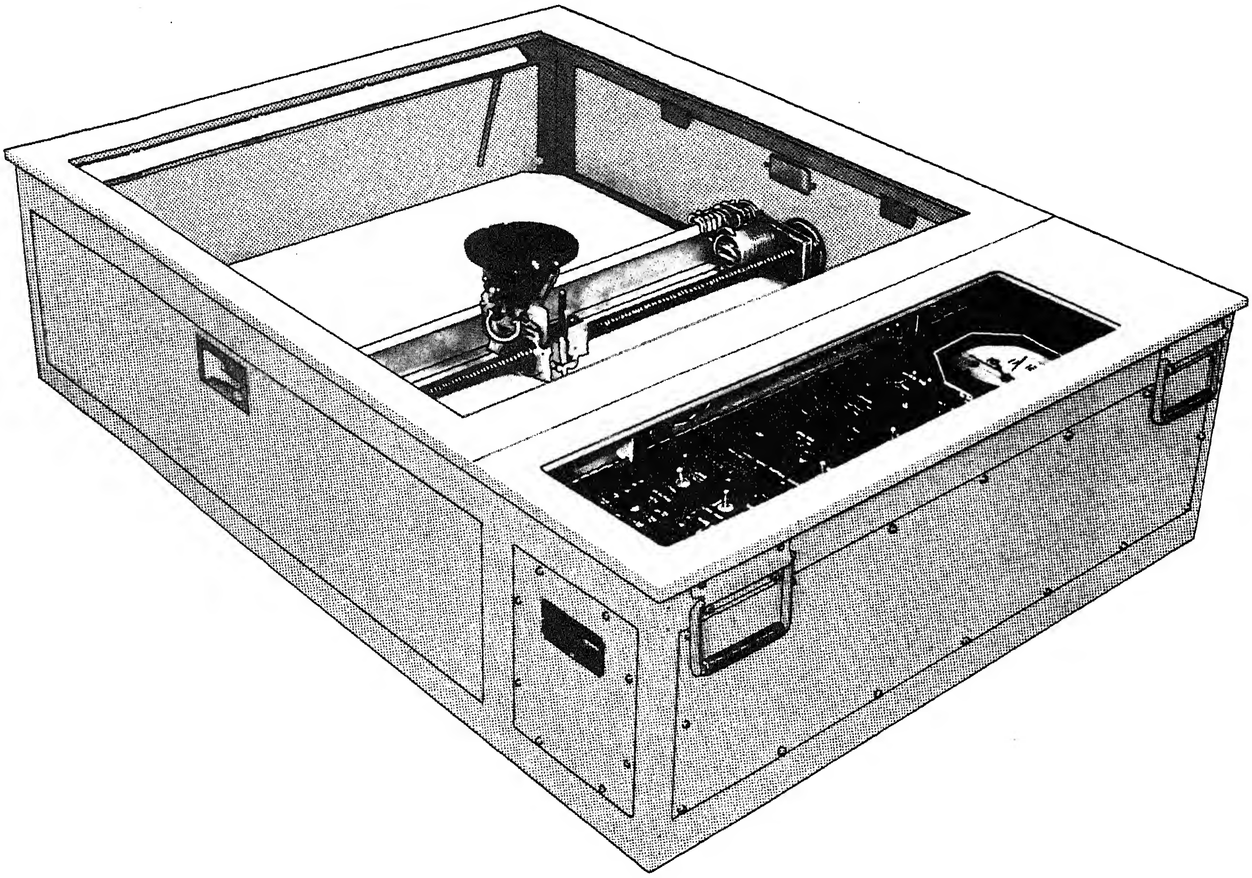
The DRT operates automatically from input signals of distance north and distance east from the step transmitters in the DRAI. The east and north distance inputs from the DRAI drives the lead and cross screw mechanisms which position the pencil carriage/projector assembly and record the ship's track. Latitude and longitude are also continuously computed from the two distance inputs and are displayed on counters. The Mk 6 Mod 4B DRT mechanisms are similar to, but more modern than, those of the Arma DRT.

NC-2 PLOTTING SYSTEMS

The NC-2 plotting system was develo primarily to aid Combat Information Cer watch personnel in plotting ship's position the position of contacts relative to own s The original system has been improved modified. There are now several different N plotting systems in use throughout the Na Each of the systems usually consists of a I or a DRAI, and a plotting table. The plot table serves the same purpose as the A DRT, plus being capable of displaying the loca of from two to four targets relative to position of the ship.

NC-2 Mod 0

The NC-2 Mod 0 (MARSLAND) was the origi plotting system. The system consists of th



40.6(40D)A

Figure 9-37.—Dead reckoning tracer Mark 6 Mod 4B.

major units—the plotting table, a dead reckoning indicator, and a data converter (fig. 9-38).

The plotting table houses three projectors, which are used for plotting the positions of own ship and two targets. The main projector assembly projects a polar diagram on the undersurface of the translucent table top. This polar diagram, the center of which represents own ship, moves in response to own ship's movements. Two smaller projectors, called target plot attachments (TPA's) project colored spots of light on the underside of the table top to represent the locations of the targets in relation to own ship. Each of the two TPA's projects a different colored spot of light—one green, the other red—so that the movement of the two targets may be followed with minimum confusion. Through the use of selector switches, either TPA may be controlled by range and bearing information from radar, sonar, fire control equipment, or other sources.

The dead reckoning indicator provides a reading on a counter of the geographical position of the ship's latitude and longitude. Use of the dead reckoning indicator is optional. The remainder of the plotting system is independent of the dead reckoning indicator and may be used without it.

The data converter receives range and speed data from the ship's radar, sonar, fire control equipment, and underwater log equipment, and converts this data into a form usable by the plotting table.

NC-2 Mod 1/1A

The NC-2 Mod 1 (Sperry) consists of two major units: a bulkhead-mounted dead reckoning

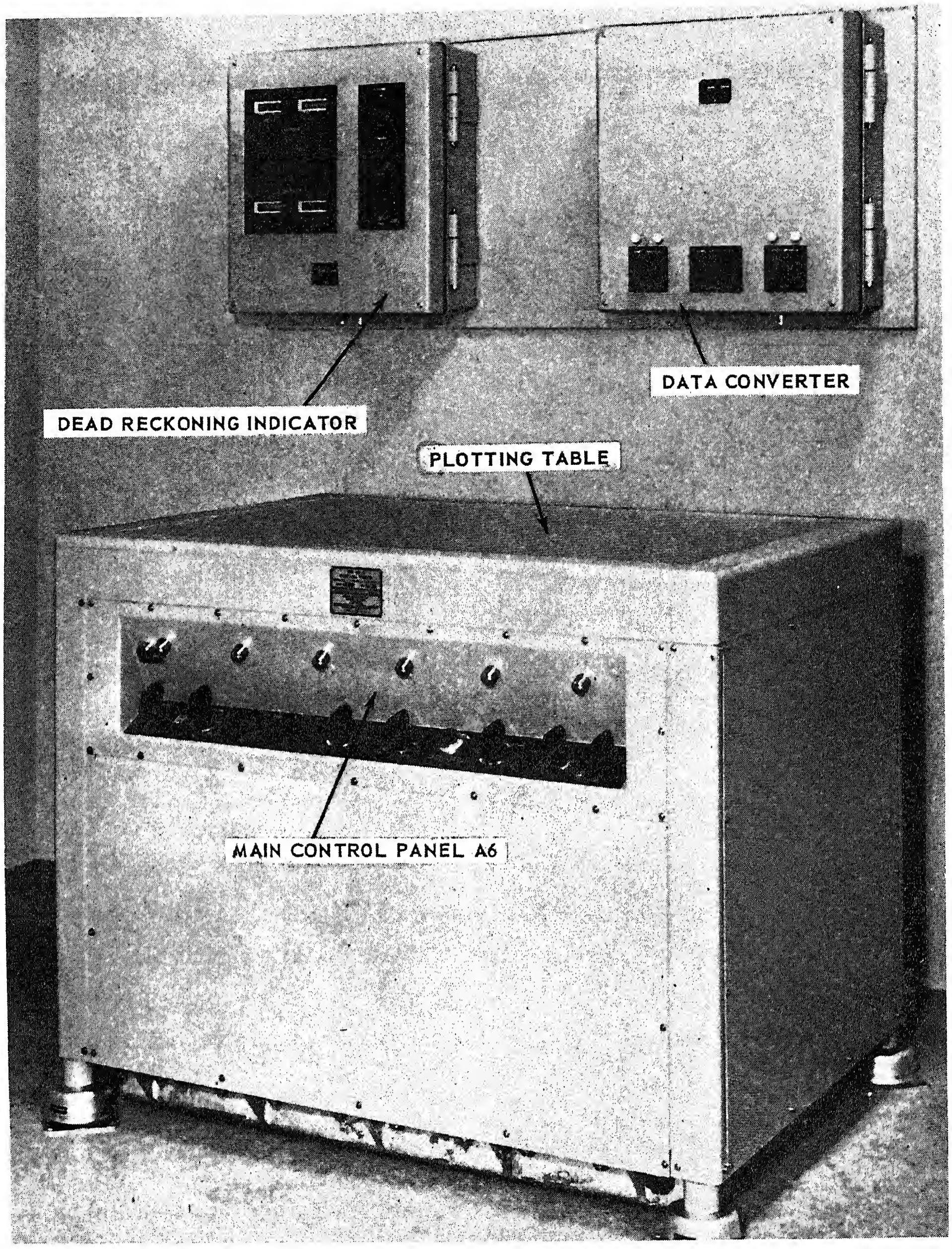


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Figure 9-38.—Plotting system Mk NC-2.

indicator (DRI) and a plotting table. The DRI employed in this system is an electromechanical computer which computes latitude, longitude, and N-S and E-W speed from ship's gyro and underwater log inputs. The plotting table is capable of providing a pictorial display of own ship's position and the position of as many four separate targets. As in the previous syste own ship is represented by the center of t polar diagram, and each target is represent by a different colored spot of light. Each the four TPA's may be controlled by inputs fr

ship's radar, sonar or fire control equipment through a selector switch arrangement.

The NC-2 Mod 1A (Sperry) system is a ruggedized version of the NC-2 Mod 1 system.

NC-2 Mod 2/2A

The NC-2 Mod 2/2A systems (Hartman) consist of two units each: (1) a dead reckoning analyzer indicator (DRAI) or a dead reckoning indicator (DRI), which computes own ship's dead reckoning position and (2) a plotting table, which displays own ship's position and the positions of four separate targets.

The NC-2 Mod 2 and Mod 2A have identical plotting tables. The systems differ in that the Mod 2 is supplied with a Mk 8 DRI and the Mod 2A is supplied with a Mk 9 Mod 0 or Mk 9 Mod 2 DRAI. Since the Mod 2A is the most common system used, we shall discuss its operation.

MK 9 DEAD RECKONING ANALYZER INDICATOR.—The Mk 9 Mod 0 DRAI (fig. 9-39) is designed for direct bulkhead mounting and

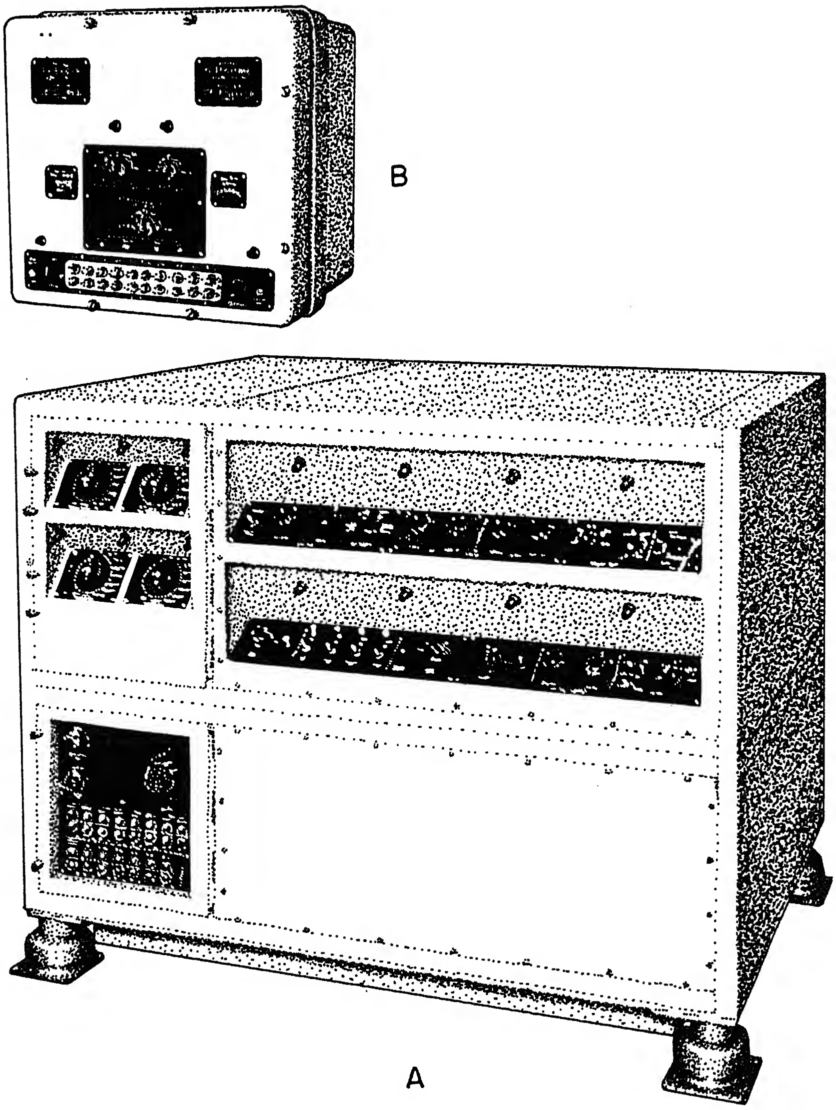

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Figure 9-39.—ASW plotting system NC-2 Mod 2-A: (A) NC-2 Mod 2 Plotting Table, (B) Mk 9 Mod 0 DRAI.

can be operated as an independent unit or in conjunction with, and as a part of, the NC-2 Mod 2A plotting system. When used with the NC-2 Mod 2A plotting system, the DRAI is electrically connected to the NC-2 Mod 2 plotting table.

There are two versions of the DRAI used with the NC-2 Mod 2 plotter: the Mk 9 Mod 0 DRAI, designated the standard unit; and the Mk 9 Mod 2 DRAI, designated the low noise or "silent" unit. Only minor differences exist between the two versions.

The DRAI is an electromechanical computer, employing digital circuits that receive inputs of own ship's speed (OSS) and own ship's course (OSC). From these inputs, the N-S and E-W components of ship's speed are computed for internal use within the DRAI and for transmission to external shipboard equipment. In addition, OSS is integrated with respect to time to give a counter readout of total distance traveled.

The N-S and E-W speed components are also integrated to provide a counter readout of distance traveled in the N-S or E-W direction. The DRAI supplies a counter readout of ship's latitude and longitude, computed from the N-S and E-W components of ship's speed. The DRAI can transmit computed values of latitude, longitude, present ship's position in N-S and E-W components, own ship's speed N-S and E-W and change of position in N-S and E-W components.

The Mk 9 DRAI is also capable of transmitting N-S and E-W distance information in a d.c. step form that may be used to drive the previously described Mk 6 Mod 4B DRT.

PLOTTING TABLE NC-2 MOD 2.—The NC-2 Mod 2 plotting table, although more modern in design, essentially performs the same functions as the other plotting tables. The plotting table is capable of graphically displaying own ship's position and four air, surface, or underwater targets on the plotting surface.

PT-512/S Tactical Display Plotting Table (formerly NC-2 Mod 3)

Unlike the other NC-2 systems, the PT-512/S tactical display plotting table consists of only one unit which is an upgraded version of the NC-2 Mod 2 plotting table. The components of the DRAI that were necessary to operate the plotting table have been relocated inside the plotting table, thus eliminating the necessity of the DRAI. The PT-512/S plotting table operates as the previously described plotting tables. It receives synchro speed and course data from the underwater log and gyrocompass and converts the data to analog signals which position the polar diagram. The four TPA's receive their inputs through a selector switch that enables the operator to select any of nine target range and bearing inputs.

The PT-512/S tactical display plotting table provides a numerical readout of ship's speed and heading. The system does not provide displays of latitude or longitude, as do the other systems. The PT-512/S plotter produces d.c. step outputs that may be used to drive the Mk 6 Mod 4B DRT.

CHAPTER 10

INTERIOR COMMUNICATIONS TELEPHONE SYSTEMS

Telephones provide a rapid and efficient means of communication between the many stations aboard ship. A satisfactory telephone system must be reliable; must not be susceptible to damage during battle; must be able to make rapid completion of calls; and must be easy to maintain. The sound-powered telephone fulfills these requirements. As the name implies, the sound-powered telephone requires no outside power supply for its operation. The sound waves produced by the speaker's voice provide the necessary energy to reproduce the voice at a remote location.

In addition to sound-powered telephones, dial telephones are provided aboard some ships. The dial telephone system is used for administrative purposes and is not depended on under battle conditions.

SOUND-POWERED TELEPHONES

The sound-powered transmitter (microphone) and receiver units in some sound-powered telephones are identical and interchangeable. Other telephones have sound-powered units that differ slightly. The principle of operation, however, is the same for both the transmitter and receiver.

As illustrated in figure 10-1 a unit consists of two permanent magnets, two pole pieces, an armature, a driving rod, a diaphragm, and a coil. The armature is located between four pole tips, one pair at each end of the armature. The spacing between the pole tips at each end is such that an air space remains after the armature is inserted between them. This air space has an intense magnetic field, which is supplied by the two magnets that are held in contact with the pole tips.

The armature is clamped rigidly at one end near one of the pairs of poles and is connected at the other end to the diaphragm by the drive rod. Hence, any movement of the diaphragm causes the free end of the armature to move toward one of the pole pieces. The armature passes through the exact center of a coil of wire that is placed between the pole pieces in the magnetic field.

The armature of a transmitter unit, when there are no sound waves striking the diaphragm, is shown in figure 10-1A. Sound waves striking the diaphragm cause it to vibrate back and forth (fig. 10-1B and C). The armature bends first to one side and then to the other, causing an alternating polarizing flux to pass through it, first in one direction and then in the other. These lines of force passing through the armature vary in strength and direction, depending on the vibrations of the diaphragm. This action induces an emf of varying direction and magnitude—that is, an alternating voltage—in the coil. The alternating voltage has a frequency and waveform similar to the frequency and waveform of the sound wave striking the diaphragm.

When the coil of a transmitter unit (fig. 10-2A) is connected to the coil of a receiver unit (fig. 10-2B), the diaphragm of the receiver unit will vibrate in unison with the diaphragm of the transmitter unit and thus generate corresponding sound waves.

The two types of sound-powered telephones installed aboard Navy ships are handsets and headsets. All telephones of a given type are built to the same military specifications regardless of the manufacturer.

HANDSETS

The type H-203/U handset is designed for general use, primarily one-to-one talking. The sound-powered transmitter and receiver units are interchangeable. S1, a nonlocking, normally open, spring-return push switch, (fig. 10-3) disconnects the sound-powered units from the line in the open position and connects the units to the line in the closed (depressed) position. Capacitor C1 is connected in parallel with the sound-powered units for tone compensation.

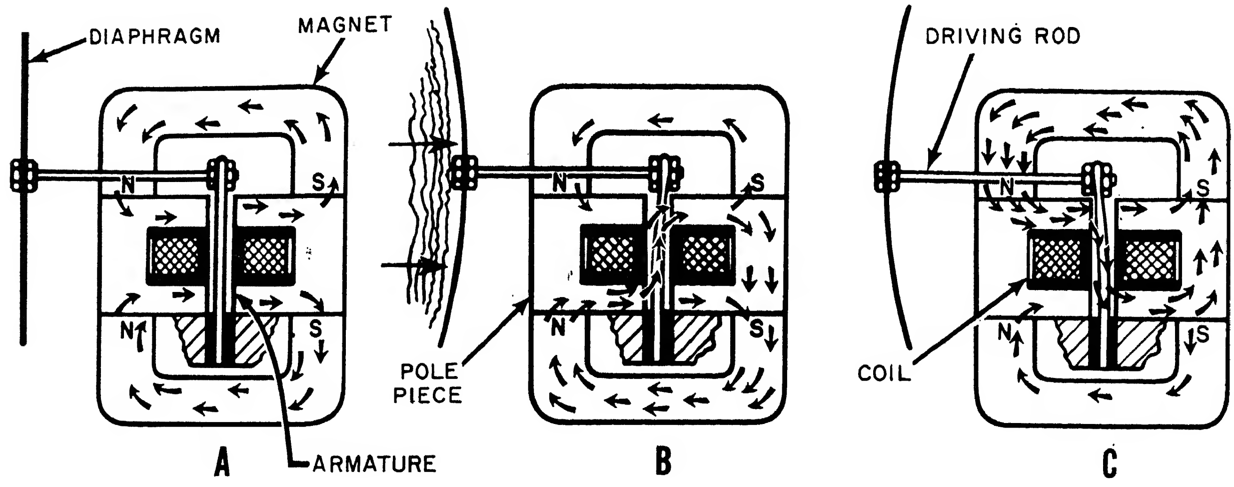

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Figure 10-1.—Sound-powered transmitter receiver unit.

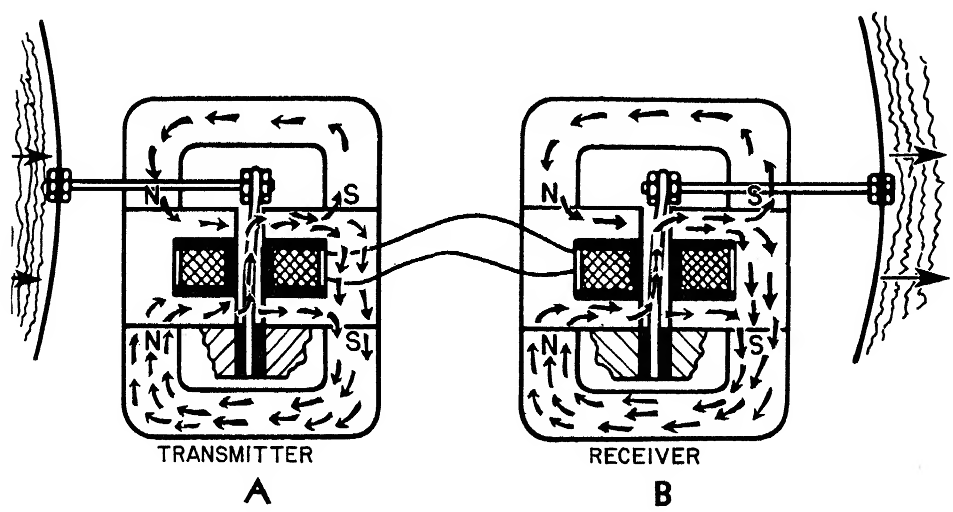

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Figure 10-2.—Operation of sound-powered units.

HEADSETS

The type H-200/U headset is designed for general use as well as for use with transistorized sound-powered telephone amplifiers.

When a sound-powered telephone set is used on the output side of a sound-powered telephone amplifier, a small d.c. voltage is placed across the set to provide an amplifier squelching circuit to avoid acoustical feedback when the local se is transmitting. Capacitor C1 (fig. 10-4) prevent the flow of d.c. through the receiver units When the press-to-talk switch is depressed d.c. current flows through the transmitter uni causing a relay in the amplifier to operat and activate the squelching circuit. Capacito C2 provides power-factor correction and im proves the acoustical quality of the sound powered headset. The sound-powered transmitte

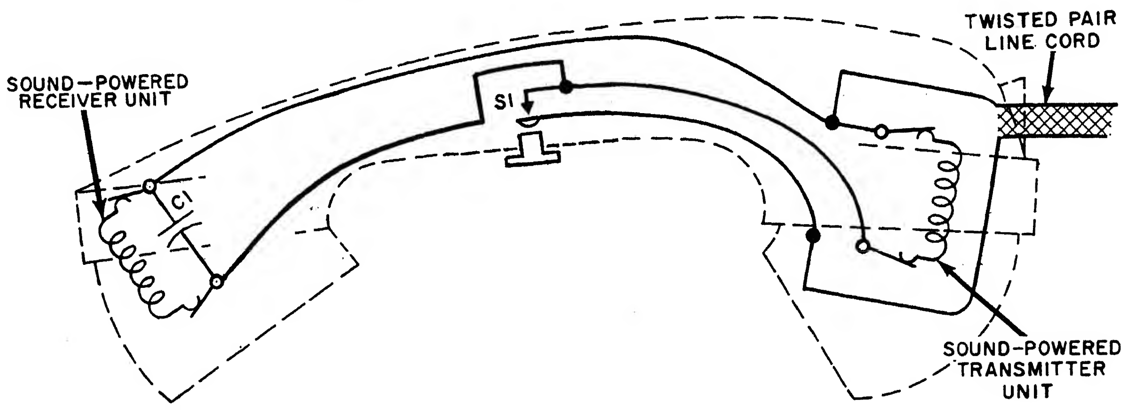

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Figure 10-3.—Wiring diagram of a sound-powered telephone handset.

and receiver units of headsets are not interchangeable.

The type H-202/U headset is a specially designed set for use in areas that have high noise levels. The receiver units are housed in noise attenuating shells—plastic caps lined with sound absorbing material. The sound-powered units are not interchangeable.

SOUND-POWERED TELEPHONE SYSTEMS AND CIRCUITS

As classified by usage there are three types of sound-powered telephone circuits:

1. The primary battle telephone circuits JA to JZ (table 10-1) include all circuits used for

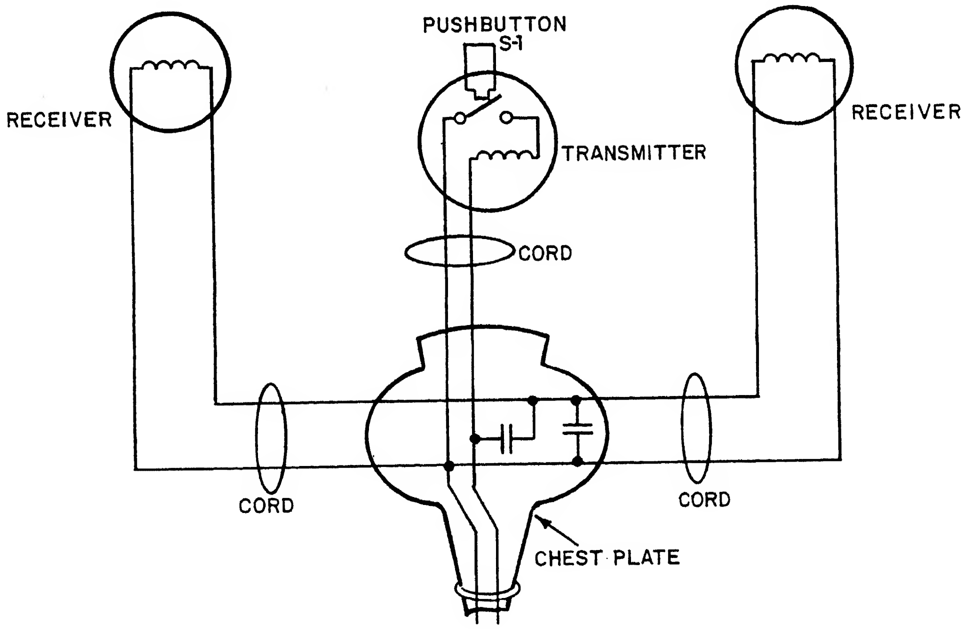

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Figure 10-4.—Wiring diagram of a sound-powered telephone headset.

Table 10-1.—Sound-Powered Telephone Circuits

Circuit	Primary Circuits Title
JA	Captain's battle circuit
JC	Weapons control circuit
10JC	Missile battery control circuit
JD	Target detectors circuit
JF	Flag officer's circuit
1JG	Aircraft control circuit
2JG	Aircraft information circuit
2JG1	Aircraft strike coordination circuit
2JG2	Aircraft strike requirement and reporting circuit
2JG3	Aircraft information circuit CATTC direct line
3JG	Aircraft service circuit
4JG1	Aviation fuel and vehicular control circuit
4JG2	Aviation fueling circuit forward
4JG3	Aviation fueling circuit aft
5JG1	Aviation ordnance circuit
5JG2	Aviation missile circuit
6JG	Arresting gear and barricade control circuit
9JG	Aircraft handling circuit
10JG	Airborne aircraft information circuit
11JG	Optical landing system control circuit
JH	Switchboard cross connecting circuit
JL	Lookouts circuit
JK	Double purpose fuse circuit
JM	Mine control circuit
JN	Illumination control circuit
JO	Switchboard operators' circuit
2JP	Dual purpose battery control circuit
4JP	Heavy machine gun control circuit
5JP	Light machine gun control circuit
6JP	Torpedo control circuit
8JP	ASW weapon control circuit
9JP	Rocket battery control circuit
10JP	Guided missile launcher control circuit

27.337

Table 10-1.—Sound-Powered Telephone Circuits—Continued

Circuit	Primary Circuits Title
10JP1	Starboard launcher circuit
10JP2	Port launcher circuit
11JP	FBM checkout and control circuit
JQ	Double purpose sight setters circuit
JR	Debarkation control circuit
JS	Plotters' transfer switchboard circuit
1JS	CIC information circuit
2JS	NTDS coordinating circuit No. 1
3JS	NTDS coordinating circuit No. 2
20JS1	Evaluated radar information circuit
20JS2	Evaluator's circuit
20JS3	Radar control officer's circuit
20JS4	Weapons liaison officer's circuit
21JS	Surface search radar circuit
22JS	Long range air search radar circuit
23JS	Medium range air search radar circuit
24JS	Range height finder radar circuit
25JS	AEW radar circuit
26JS	Radar information circuit
31JS	Track analyzer No. 1 air radar information check
32JS	Track analyzer No. 2 air radar information check
33JS	Track analyzer No. 3 air radar information check
34JS	Track analyzer No. 4 air radar information check
35JS	Raid air radar information circuit
36JS	Combat air patrol air radar information circuit
61JS	Sonar information circuit
80JS	ECM plotters' circuit
81JS	ECM information circuit
82JS	Supplementary radio circuit
JT	Target designation control circuit
1JV	Maneuvering and docking circuit
2JV	Engineers' circuit (engines)

27.337

Table 10-1.—Sound-Powered Telephone Circuits—Continued

Circuit	Title
	Primary Circuits
3JV	Engineer's circuit (boiler)
4JV	Engineer's circuit (fuel and stability)
5JV	Engineer's circuit (electrical)
6JV	Ballast control circuit
11JV	Waste control circuit
JW	Ship control bearing circuit
JX	Radio and signals circuit
2JZ	Damage and stability control
3JZ	Main deck repair circuit
4JZ	Forward repair circuit
5JZ	After repair circuit
6JZ	Midships repair circuit
7JZ	Engineer's repair circuit
8JZ	Flight deck repair circuit
9JZ	Magazine sprinkling and ordnance repair circuit forward
10JZ	Magazine sprinkling and ordnance repair circuit aft
11JZ	Gallery deck and island repair circuit
	Auxiliary Circuits
XJA	Auxiliary captain's battle circuit
X1JG	Auxiliary aircraft control circuit
X1JV	Auxiliary maneuvering and docking circuit
XJX	Auxiliary radio and signals circuit
X2JZ	Auxiliary damage and stability control circuit
	Supplementary Circuits
X1J	Ship administration circuit
X2J	Leadsman and anchor control circuit
X3J	Engineer watch officer's circuit
X4J	Degaussing control circuit
X5J	Machinery room control circuit
X6J1	Electronic service circuit
X6J7	ECM service circuit
X6J11-14	NTDS service circuits
X7J	Radio-sonde information circuit

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Table 10-1.—Sound-Powered Telephone Circuits—Continued

Circuit	Supplementary Circuits Title
X8J	Replenishment-at-sea circuit
X9J	Radar trainer circuit
X10J	Cargo transfer control circuit
X10J1	Cargo transfer circuit-Lower decks
X10J10	Cargo transfer circuit-Upper decks
X11J	Captain's and admiral's cruising circuit
X12J	Capstan control circuits
X13J	Aircraft crane control circuits
X14J	Missile handling and nuclear trunk crane circuit
X15J	SINS information circuit
X16J	Aircraft elevator circuit
X17J	5-inch ammunition hoist circuit
X18J	Machine gun ammunition hoist circuits
X19J	Missile component elevator circuit
X20J	Weapons elevator circuits
X21J	Catapult circuit
X22J	Catapult steam control circuit
X23J	Stores conveyor circuit
X24J	Cargo elevator circuit
X25J	Sonar service circuit
X26J	Jet engine test circuit
X28J	Dumbwaiter circuit
X29J	Timing and recording circuit
X34J	Alignment cart service circuit
X40J	Casualty communication circuit
X41J	Special weapons shop service circuit
X42J	Missile assembly and handling circuit
X43J	Weapons system service circuit
X44J	ASROC service circuit
X45J	Special weapons security circuit
X50J	Fog foam circuit
X61J	Nuclear support facilities operations and handling circuit

27.337

the main channels of communications in controlling the armament, engineering, damage control, and maneuvering of a ship.

2. The auxiliary battle telephone circuits XJA to XJZ include circuits duplicating certain primary battle telephone circuits as alternates in case of damage. The wiring of the auxiliary circuits is separated as much as practicable from the wiring of the corresponding primary circuits to lessen the possibility of battle damage to both circuits.

3. The supplementary telephone circuits X1J through X61J consist of circuits that provide communications for various administrative, service, and secondary control functions.

The various sound-powered telephone systems are classified by construction into three groups: switchboard circuits, switchbox circuits, and string-type circuits.

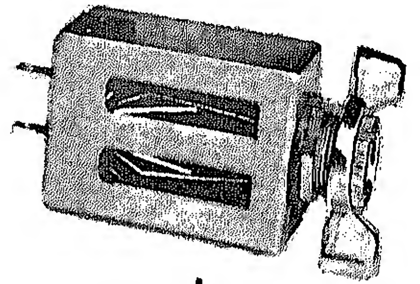
Switchboard Circuits

A switchboard circuit (fig. 10-5) has the line for each telephone station connected to an individual switchjack. The switchjack (fig. 10-5A) is a combination line cutout switch and telephone jack. Each switchjack is mounted in rows on the switchboard (fig. 10-5B). The line cutout switch portion of the switchjack either connects or disconnects a telephone station from its circuit. The jack portion of the switchjack is used with a patching cord to either parallel the telephone station associated with a particular switchjack to another circuit or serves to parallel two entire circuits.

Most large combatant ships have several sound-powered telephone switchboards installed in different centrally located and protected control stations. Each switchboard usually has facilities to control several switchboard circuits.

Switchbox Circuits

A switchbox circuit has the line for each telephone station connected to one of the individual cutout switches which are mounted in a switchbox (fig. 10-6). Each cutout switch either connects or disconnects an individual telephone station to a circuit.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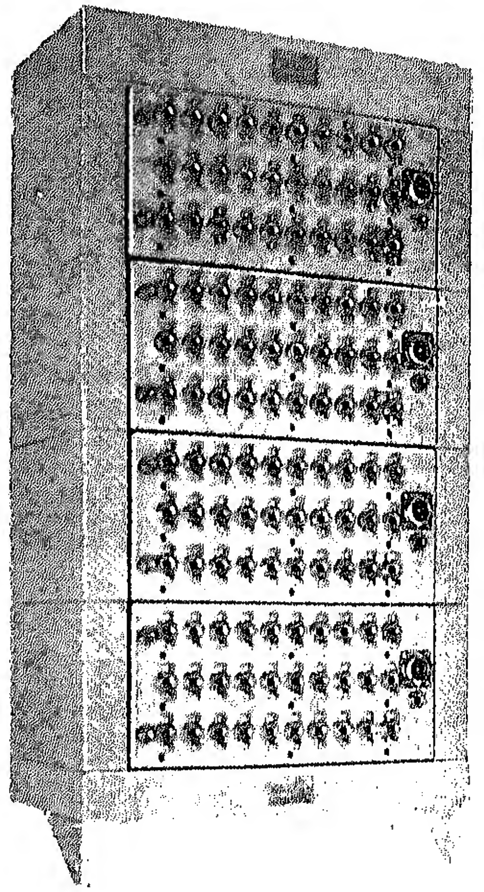
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Figure 10-5.—Sound-powered telephone swit[ch]board and switchjack.

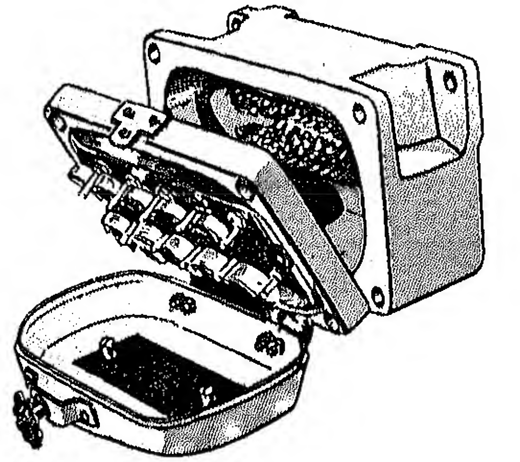

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Figure 10-6.—Sound-powered telephone switchbox.

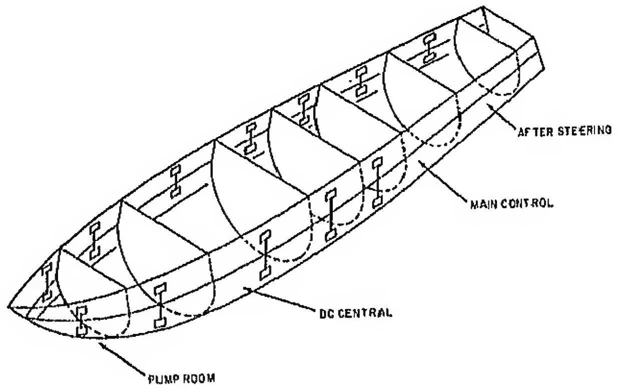

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Figure 10-7.—X40J circuit risers.

Some of the switches may be used as tie switches connected to the circuit bus in other switchboxes. When these tie switches are closed, the circuits in the two boxes are paralleled.

Usually, there is only one switchbox for each circuit. Telephone switchboxes function primarily as small ACO switchboards. The switchboxes are located at the principal station on the circuit, and contain either 10 or 20 switches.

String-Type Circuits

A string-type circuit consists of a series of telephone station jackboxes connected in parallel to a single line. There are no action cutout switches for individual stations.

The X40J, casualty communication circuit, which is classified as a string-type circuit, consists of individual riser cables running from jackboxes in engineering spaces and steering gear rooms to four gang jackboxes on the main deck, see figure 10-7.

All horizontal runs are made as required by damage control parties with rolls of cables, which are made up on reels with plugs on each end.

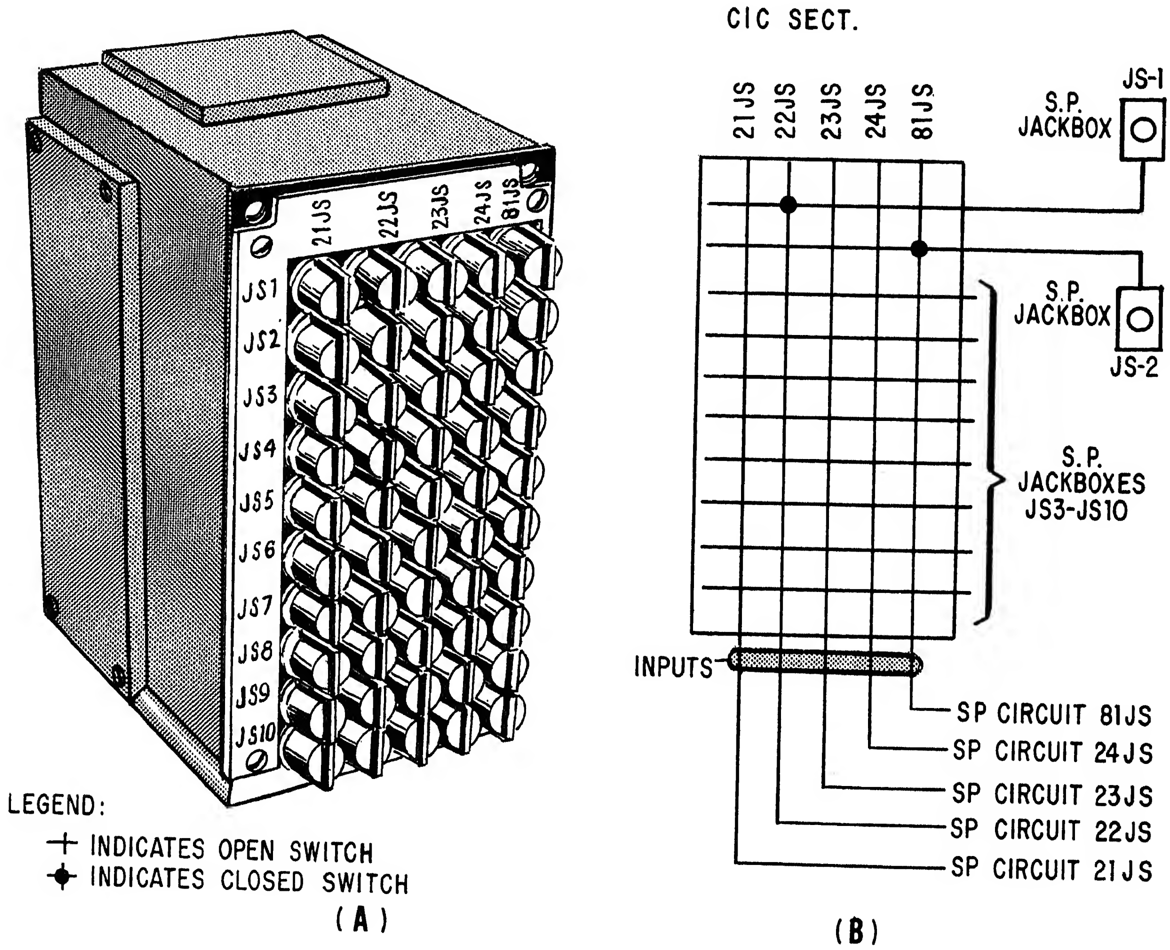
Plotters Transfer Switchboards

Plotters transfer switchboards (fig. 10-8) employ switches arranged in a matrix form. Several different sound-powered jackboxes and circuits are connected to these switchboards. As shown in figure 10-8B, the closing of any one of the five switches associated with each jackbox permits the jackbox to be connected to one of the sound-powered circuits. In figure 10-8B jackbox JS1 is shown connected to sound-powered circuit 22JS, and jackbox JS2 is shown connected to sound-powered circuit 81JS. Any of the remaining jackboxes, JS3 - JS10 may be connected to one of the five sound-powered circuits by simply closing the associated switch.

Plotters transfer switchboards are found in areas aboard ship such as CIC, where the tactical situation governs the sound-powered circuit to which the plotters are to be connected. For instance, the situation may require that the CIC plotters connected to jackboxes JS1 - JS5 be connected to circuit 21JS, while the plotters connected to jackboxes JS6 - JS10 are connected to circuit 22JS. Another situation may call for another arrangement. The plotters transfer switchboard permits the plotters to be shifted from one circuit to another quickly and efficiently as the situation dictates and eliminates the necessity of installing multiple circuit phone boxes at each location.

Selector Switches

Selector switches (fig. 10-9) are located at the most important stations throughout the ship to enable the officer in charge, or his talker, to connect his telephone to any one of a group of circuits without having to change from one jackbox outlet to another.



36.69

Figure 10-8.—Plotters transfer switchboard.

SOUND-POWERED TELEPHONE CIRCUIT MAINTENANCE

Preventive maintenance for sound-powered telephone circuits consists of routine tests, inspections, and cleaning, which should be conducted in accordance with current PMS requirements. Cleanliness is essential to the proper operation of sound-powered telephone equipment because of the low voltages and currents involved.

SOUND-POWERED TELEPHONE AMPLIFIER AM-2210/WTC

In high noise-level areas such as engineering control, steering enginerooms, and gun mounts, it is often difficult, if not impossible, to hear sound-powered telephone conversations, even over the best maintained circuits. Recognizing this, the Navy developed the sound-powered telephone amplifier to assist communications

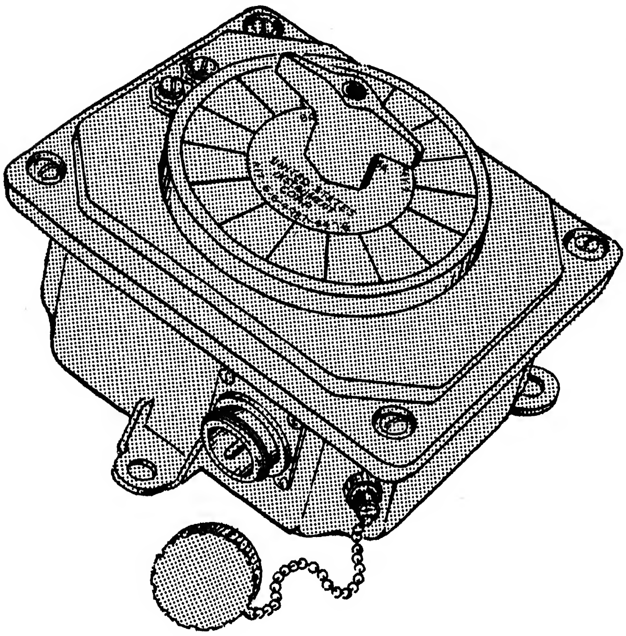


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Figure 10-9.—Selector switch.

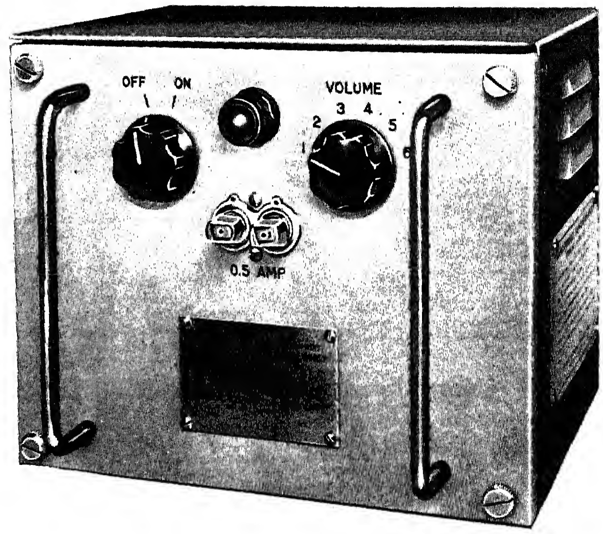

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Figure 10-10.—Sound-powered telephone amplifier AM-2210/WTC.

in these vital areas. The transistorized AM-2210/WTC, presently in wide use throughout the fleet, meets the following requirements with a high degree of reliability:

1. Amplifies one-way communications in a two-way sound-powered system using existing sound-powered headsets. (That is, it amplifies the voice to a gun mount but not the voice from it.)

2. Supplies six outlet headsets and two loudspeakers.

3. Is fail-safe on power loss or component failure. (Allows normal level conversation.)

4. Operates on 115-volt 60-hertz a.c. power.

When operating under normal conditions, the AM-2210/WTC (fig. 10-10) receives signals from a remote telephone line, amplifies them, and transmits the amplified signal to as many as six local headsets and two loudspeakers. Direct talk-back between any of the six headsets and the remote line is carried out at normal sound-powered level, the amplifier being disconnected upon actuation of any of the press-to-talk switches on any of the six local headsets.

When the amplifier is deenergized or when certain predetermined casualties occur, the fail-safe feature permits direct two-way communications between local and remote stations at a normal sound-powered level.

Electrically the unit consists of an audio amplifier, a switching circuit, and a power supply. Equipment reliability is increased by the use of transistors in the audio and switching circuits.

Although by no means trouble free, the AM-2210/WTC is a reliable unit. When trouble does occur, it often is caused by improper operating procedures or by a failure in external circuitry.

CALL-BELL SYSTEMS

Call-bell systems provide a means of signaling between stations in a ship. These systems consist of circuits E and A.

CIRCUIT E

Circuit E provides a means of signaling between stations on sound-powered telephone circuits and outlets on voice tubes. Aboard

large ships this circuit may be designated as follows:

EM—Self-contained circuits with magneto call signal stations: Provides for selective calls over COMMON talk circuits.

MJ—Self-contained circuits with magneto call signal stations: Provides for selective calls over SELECTED talk circuits.

EP—Protected call circuits with cable runs protected behind armor.

EPS—Unprotected signal lines supplied from an EP circuit through separate protected fuses at the calling station.

EPL—Unprotected circuits supplied from an EP circuit through a protected local cut-out switch at the station called.

EX—Exposed call circuits with cable runs not protected behind armor.

In addition, circuit E has the following functional designations:

1E—Cruising and miscellaneous

2E—Ship control

3E—Engineering

4E—Aircraft control

5E—Fire control

11E through 15E—Turrets I through V

For example, a circuit designated as 3EP is an engineering call-bell circuit with cables protected behind armor.

Circuits EP and EX require an outside source of power and include bells, buzzers, or horns installed at selected sound-powered telephone stations and at some voice tubes. Watertight and nonwatertight pushbuttons, or spring return rotary switches, are provided at all signaling stations to complete circuits to the station called. Circuits EM and MJ are self-contained magneto-powered cell systems which utilize IC/D call signal stations, normally called growlers or howlers (fig. 10-11). They are used in conjunction with sound-powered telephone systems.

The call signal stations consist of a rotary selector switch, a hand-operated magneto generator, and a howler unit. Selective calling of up to 16 individual stations is possible. When used in the circuit EM configuration, the sound-powered telephone and call systems are independent of each other. In the MJ configuration the sound-powered telephone and call systems are combined. Through the use of a relay within the IC/D Call Signal Station, the sound-powered conversation is transmitted from station to station via the signaling leads. In the EM configuration only one conversation is possible at one time. With the MJ configuration up to 15 separate conversations are possible at one time.

CIRCUIT A

Circuit A is for the convenience of the ship's officers in calling pantry attendants and orderlies. Calls are provided from cabins, staterooms, and wardrooms to the respective pantries and orderlies. Circuit A calls are provided also from all sickbay berths and isolation wards to the attendant's desk in the sick bay. Circuit A consists of bells or buzzers at the orderly and pantry stations and nonwatertight pushbuttons in the various cabins, staterooms, and messrooms. Where a station is to be signaled by more than one pushbutton, a drop-type annunciator is installed in addition to the bell or buzzer.

A simplified call-bell circuit is shown in figure 10-12. This simplified circuit applies to circuit A as well as to circuit E.

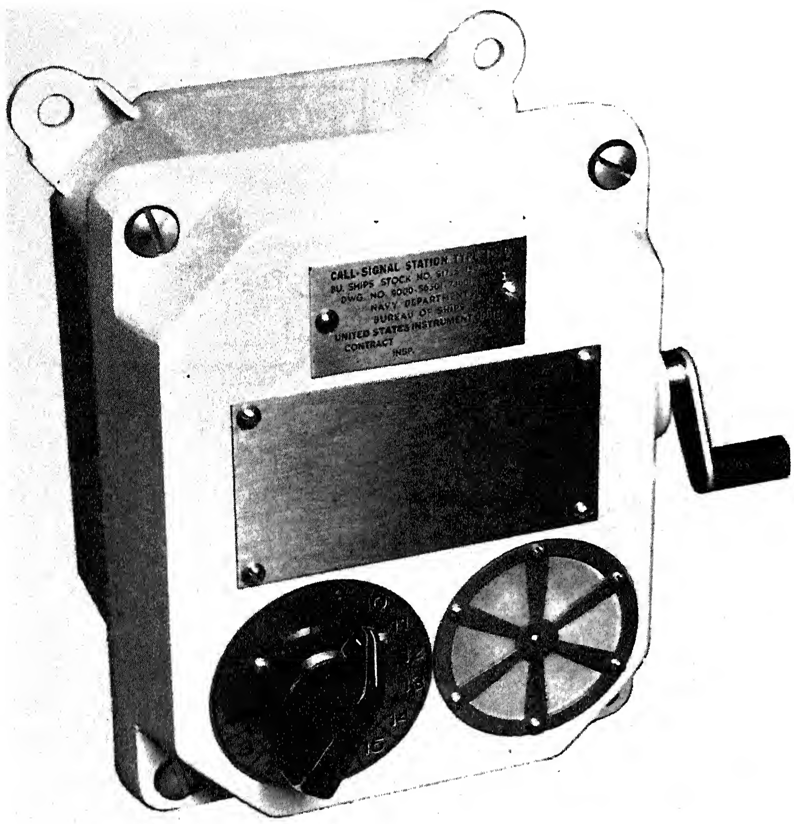
The upper branch circuit, with one bell and one pushbutton in series with each other, is used to call single station from one location.

The center branch circuit, with two pushbuttons in parallel with each other and in series with the bell, is used to operate one bell from two remote locations.

The lower branch circuit, with two bells in parallel with each other and in series with one pushbutton, is used to operate two bells from one location.

ANNUNCIATORS

Stations (such as the bridge) that are served by several sound-powered circuits with their associated call-bell systems require some aid to distinguish between the sounds of the various



74.66X

Figure 10-11.—IC/D call signal station.

ignals. The need for this aid is especially ecessary when several magneto call stations re used because of the similarity of the sound ıey emit. In addition, some means is needed ith A call systems to aid in determining which tateroom is signaling. Annunciators are used ith A and E call-bell systems to fulfill these eeds.

Annunciators used with E call circuits are f the drop type. The drop, or target, is emossed with the designation of the sound-powered ircuit with which it is associated and is eld mechanically in the non-indicating posiion. When the circuit is energized (by pushbutton or by a turn of the crank of magneto call signal station at the calling tation), an electro-magnet causes the target drop to the indicating position. The drops re returned to their normal, or nonindicating ositions by a hand-operated reset button.

Annunciators used with A call circuits are similar to those used with E call circuits except, that in A call circuits, the drop is embossed with the number of the stateroom, or location of the calling station, instead of the circuit letter.

An additional feature of annunciators is the ability to use a common audible signaling device controlled by relays in the annunciator.

DIAL TELEPHONE SYSTEMS

In addition to sound-powered telephone systems, dial telephone systems are installed on the Navy's combatant ships. The dial telephone system, or circuit J, is primarily an administrative circuit which provides complete selective

telephone communication throughout the ship. The system is also used to supplement other communication facilities for ship control, fire control, and damage control. The capacity of the system varies with the size and needs of the particular ship.

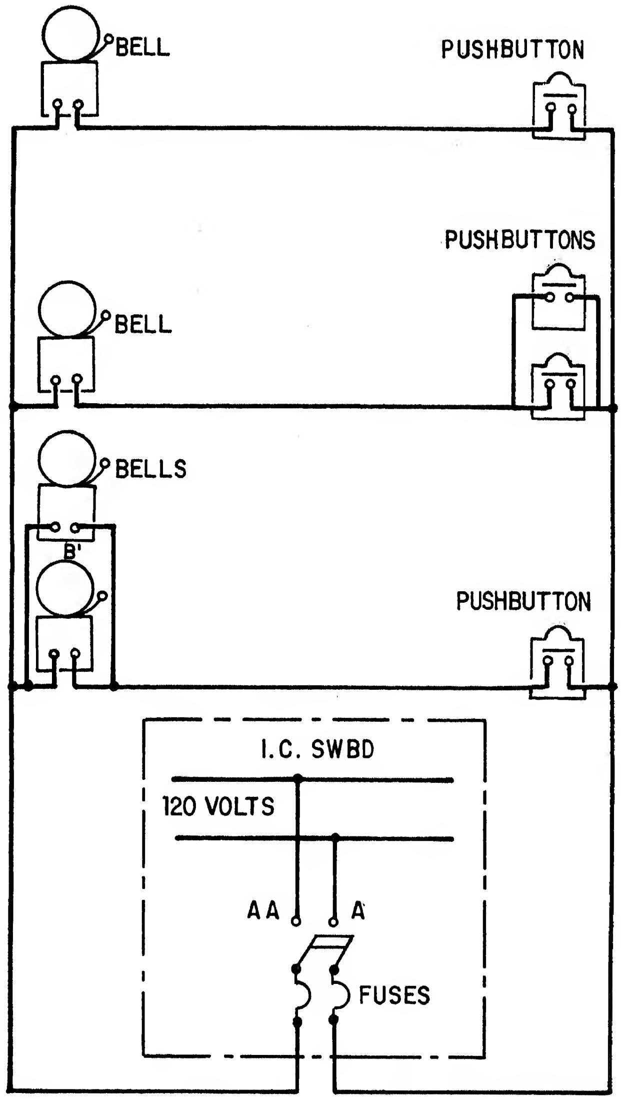
A dial telephone system consists of a group of telephones with lines so arranged at a central point that any two telephones in the system can be interconnected. In a dial telephone system, the connections between the telephones are completed by remotely controlled switching mechanisms.

The switching mechanisms of a dial telephone system are controlled at the calling telephone by a dial on the telephone instrument. When the dial is operated, a series of interruptions, or impulses, occur in the current flowing in the line circuit. The number of impulses sent out by the dial corresponds to the digit dialed. These impulses cause the automatic switches to operate and to select the called telephone.

A typical dial telephone system (fig. 10-13) consists of: telephone station equipment, made up of telephone instruments which may receive or initiate calls; dial telephone switchboard equipment that includes the switching necessary to interconnect the line stations; power equipment that furnishes normal and emergency power for the system; and accessory equipment used to interconnect the ship's telephone equipment with shore telephone equipment when the ship is in port.

TELEPHONE STATION EQUIPMENT

The telephone station equipment (sometimes referred to as line stations) consists of different types of telephone instruments. The telephone instrument is a unit which transmits and receives speech and signals the desired station. It comprises a transmitter, receiver, dial and ringer. The transmitter changes sound into an undulating current which is sent over an electrical circuit. The receiver changes the undulating current back into sound. The dial, when operated, causes a series of interruptions (impulses) in the current flowing in the line circuit. The ringer provides an audible signal when the station is called.

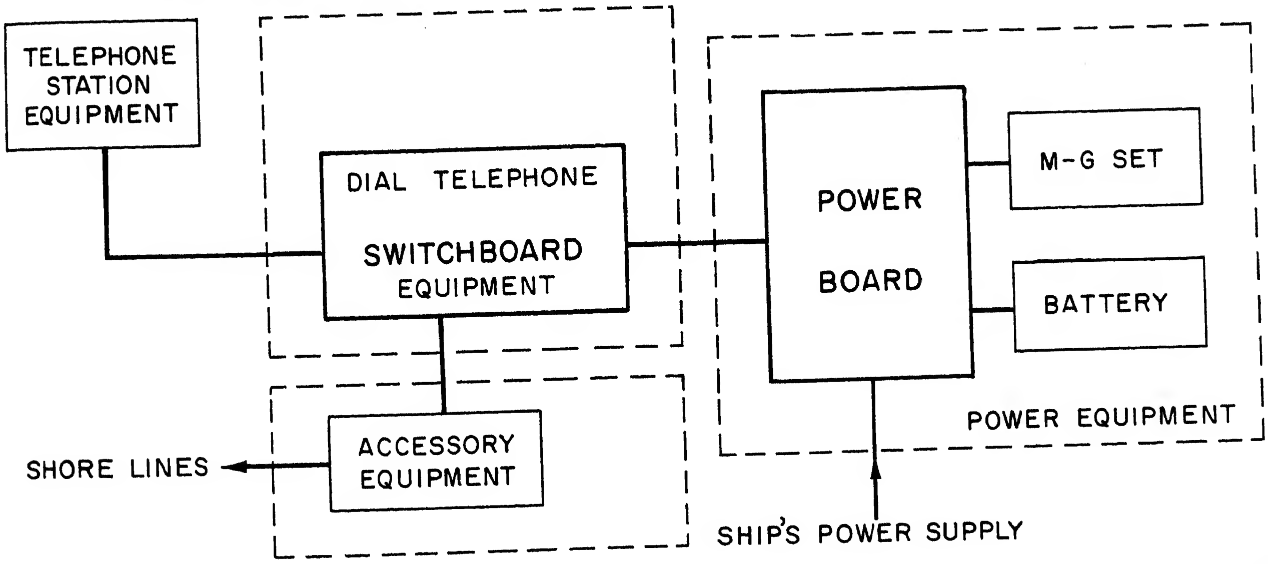


27.292
Figure 10-12.—Simple call-bell system.

Types of Telephones

The types of telephones furnished with dial telephone systems are illustrated in figure 10-14. The types differ mainly in the form in which the components are assembled. The components perform the same function, but the enclosure and method of mounting for each type is of special design.

The TYPE A desk set telephone (fig. 10-14A) is installed in staterooms, cabins, offices, and



7.76(140B)

Figure 10-13.—Block diagram of the dial telephone system.

similar stations. The desk set consists of a phenolic case (containing the ringer, dial and other working parts), a handset, and connecting cord with a terminal block for making the line connections.

The TYPE F bulkhead telephone (fig. 10-14B) can be installed in any station except those on weather decks. The type F telephone is a non-watertight unit designed for mounting on a bulkhead or on the side of a desk. It consists essentially of a metal housing on which are mounted the handset, dial, and ringer. The line connections are made at a terminal block inside the housing.

The TYPE C splashproof telephone (fig. 10-14C) is installed at stations on weather decks and at any other stations exposed to moisture. The type C telephone is designed for bulkhead mounting and consists essentially of a metal housing on which are mounted the handset and dial which are enclosed in a splashproof box.

The TYPE G telephone (fig. 10-14D) is used in all new dial telephone system installations and is used to replace the type A, C, and F telephone of older installations as they wear out. The basic type G telephone is available with three different enclosures which adapt it to use in place of the A, C or F telephones.

DIAL TELEPHONE SWITCHBOARD EQUIPMENT

The dial telephone switchboard is the switching center of the dial telephone system. Mounted in this switchboard are all telephone switching mechanisms, control circuits, part of the testing equipment, and most of the supervisory alarm signals.

These switch mechanisms automatically perform the following functions:

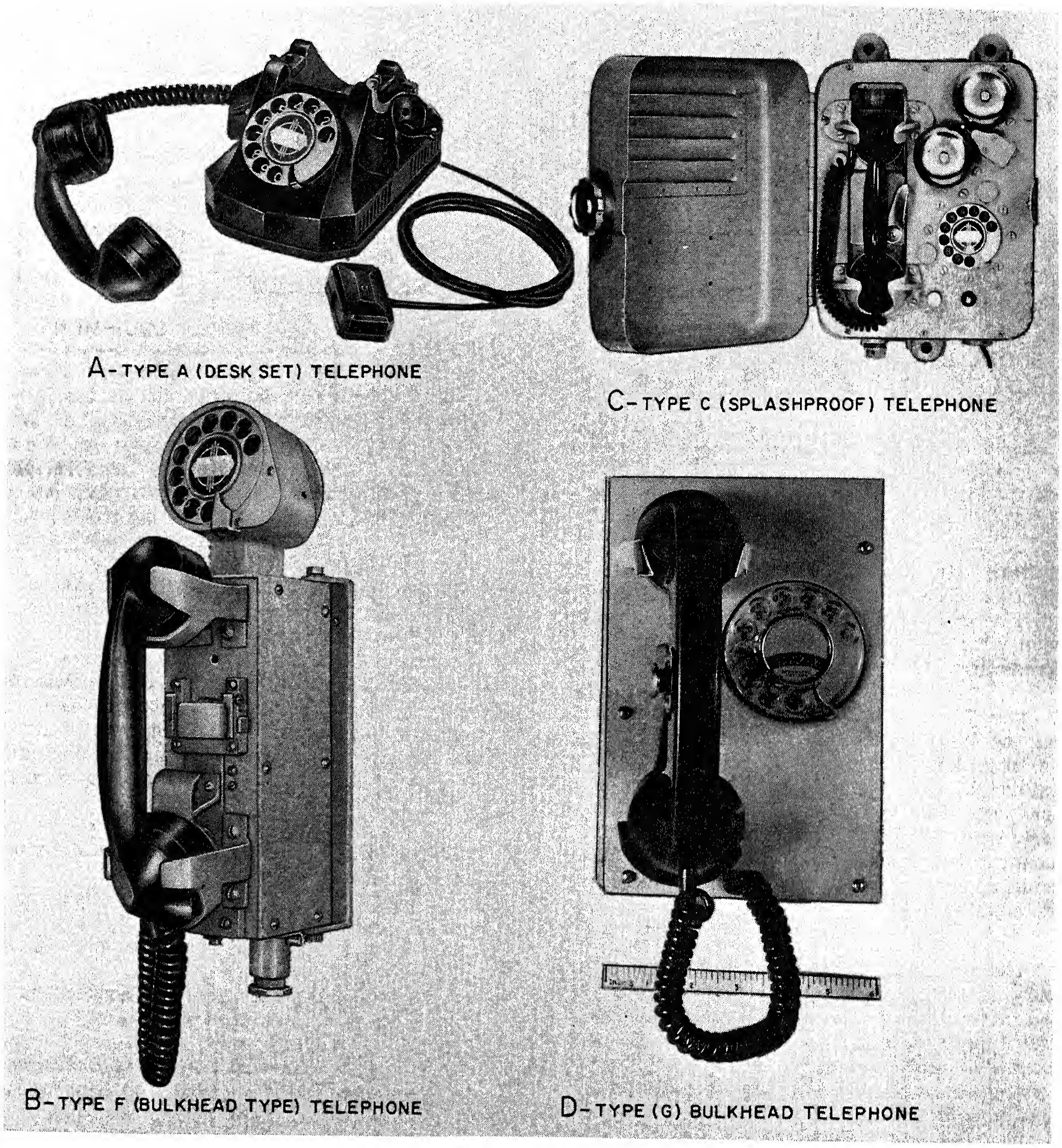
1. Locate a station desiring to make a call.

2. Respond to dial impulses and extend the calling station to the called station.

3. Ring the called station and, if necessary, select between the two parties on a party line.

4. Supply various tones, such as dial tone, busy tone, and ring-back tone, as required.

At present there are at least four major types of dial telephone switchboard equipment employed in the Navy. In this section two of these types of equipment, the Automatic Electric



7.83

Figure 10-14.—Telephone station equipment.

and the Marine Dialmaster, plus their basic operating principles will be discussed.

Automatic Electric
Switchboard Equipment

Until recently the Automatic Electric Switchboard equipment (figs. 10-15 and 10-16) was the only type employed aboard U.S. Navy surface ships. This equipment was furnished in various sizes capable of servicing from 50 to more than 600 telephone stations. The Automatic Electric Switchboard equipment utilizes the Strowger switch as the basic switching element to perform the functions required of a dial telephone switchboard.

SWITCHING.—The Strowger switch (fig. 10-17) is an electromechanical device which, as used in the Automatic Electric Telephone System, extends the connection from the calling to the called telephone. The assembly of fixed electrical contacts, arranged in ten levels, generally with ten sets of contacts to a level, is called a wire bank. The electrical members which make contact with the selected set of contacts in the wire banks are called wipers. These wipers are connected to the switch shaft.

The switch mechanism elevates the shaft vertically (therefore the wipers) and then rotates the shaft (and wipers). Because of this vertical and rotary motion, the Strowger switch is often referred to as a two-motion switch.

The Strowger switch is the basic switch of the system being used as a finder, connector, and selector, in each case employing slightly different electrical and mechanical variations. Figure 10-17 shows the mechanical elements common to all Strowger switches. As one of its variations, the finder switch has an additional set of vertical wipers connecting to a vertical bank.

LINE GROUPING AND NUMBERING.—The basic system of grouping provides for a maximum of 100 lines, as shown in figure 10-18. The horizontal dashes represent 100 pairs of metallic contacts. There are 10 horizontal levels and 10 sets of contacts in each level. Thus, the tens digit of the called number represents the level, whereas the units digit represents the individual pair of contacts in the level.

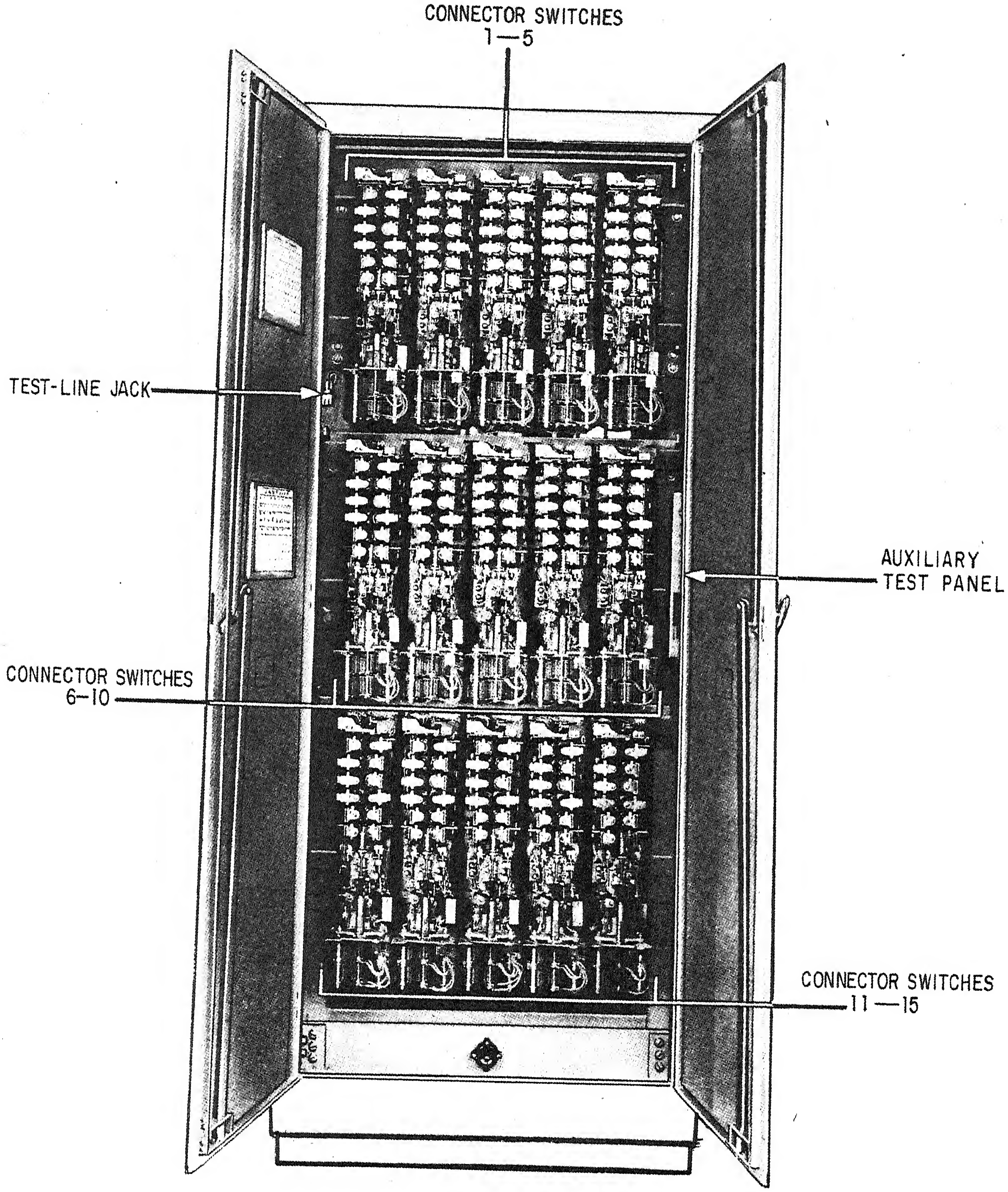
Numbers beginning with 1 are in the first, or bottom, level, numbers beginning with 2 are in the second level, and so on. This arrangement causes the digit 0 to be used to represent 10 steps so that the 10th, or top, level is indicated by the symbol for zero. Also, the 10th pair of contacts in each level is indicated by the symbol for zero. Groups of 10 lines are referred to as lines 11-10, 21-20, 31-30, and so forth. The first 10 lines consist of 11-10, and the last 10 consist of 01-00.

Each pair of metallic contacts is connected to a pair of wires that lead to a particular telephone. These contacts are actually contained in a Strowger switch, arranged in the arc of a circle with the vertical rows parallel to the axis of the cylinder. The entire assembly of contacts is called a wire bank.

These wire banks are commonly referred to by the type of switch with which they are associated, such as finder bank, connector bank, etc.

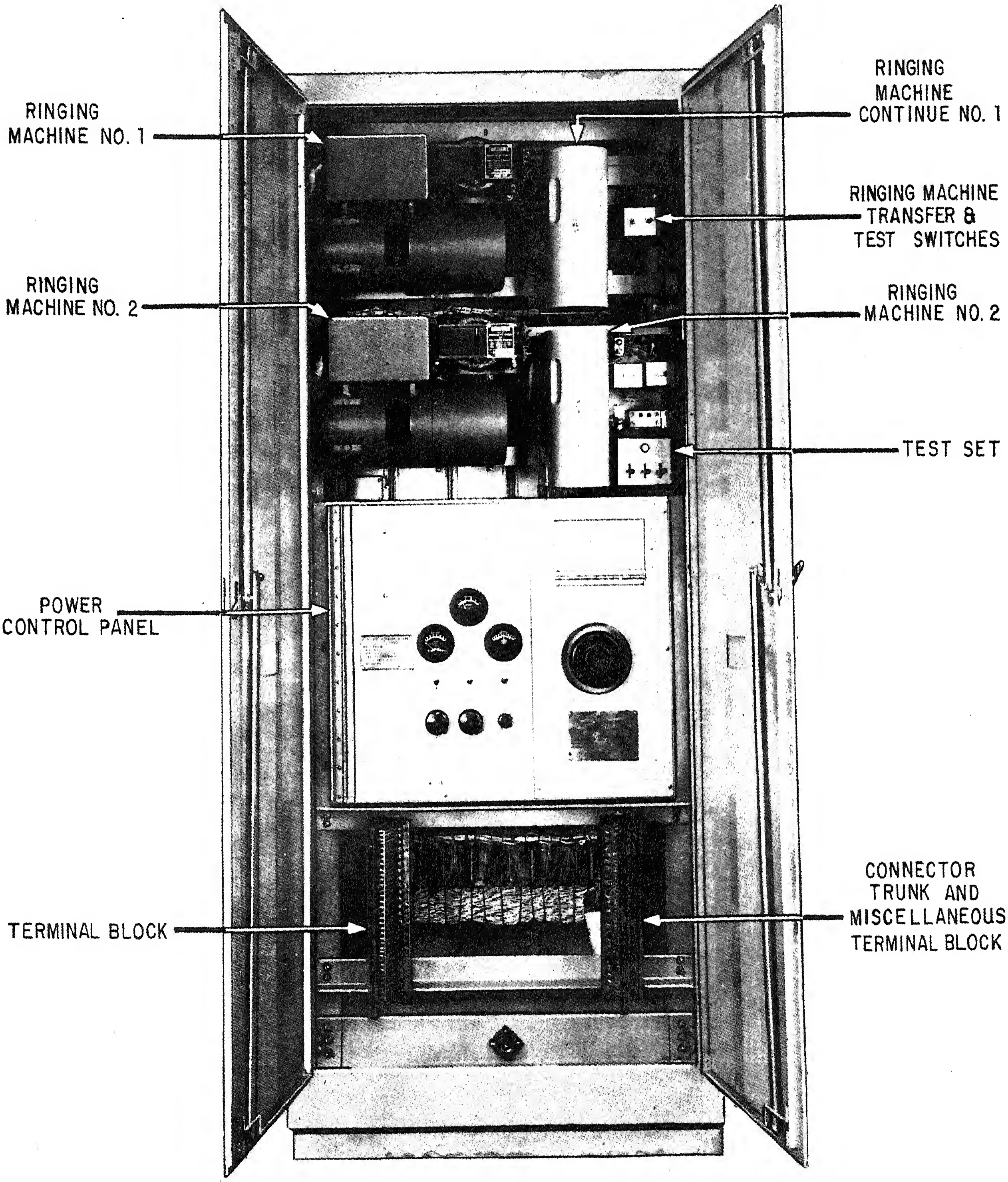
A pair of metallic wipers mounted on the shaft of the Strowger switch is shown (fig. 10-18) at the lower left-hand corner of the wire bank. These wipers are moved under the control of the dial on the calling telephone. For example, if the calling telephone calls telephone No. 32, when digit 3 is dialed, the wipers step UP to the third level in the wire bank. When digit 2 is dialed, the wipers rotate IN 2 steps on the third level to connect the calling telephone with telephone 32. Likewise, to connect the calling telephone with telephone 67, the wipers step UP 6 steps and then rotate IN 7 steps.

BASIC 100-LINE SYSTEM—The system described with reference to figure 10-18 is not practical because only the calling telephone can originate calls. Therefore, the basic 100-line system (fig. 10-19) was implemented. Each telephone is connected to the wipers of its own connector switch. The wiper of each switch can be stepped up and rotated in, under the control of the dial of the calling telephone. One connector bank with its wipers and the mechanism necessary to step the wipers up and in constitute a CONNECTOR SWITCH. A connector switch is referred



27.389

Figure 10-15.—Connector cabinet, Automatic Electric Telephone Switchboard.



27.390

Figure 10-16.—Automatic Electric Telephone Switchboard miscellaneous equipment cabinet.

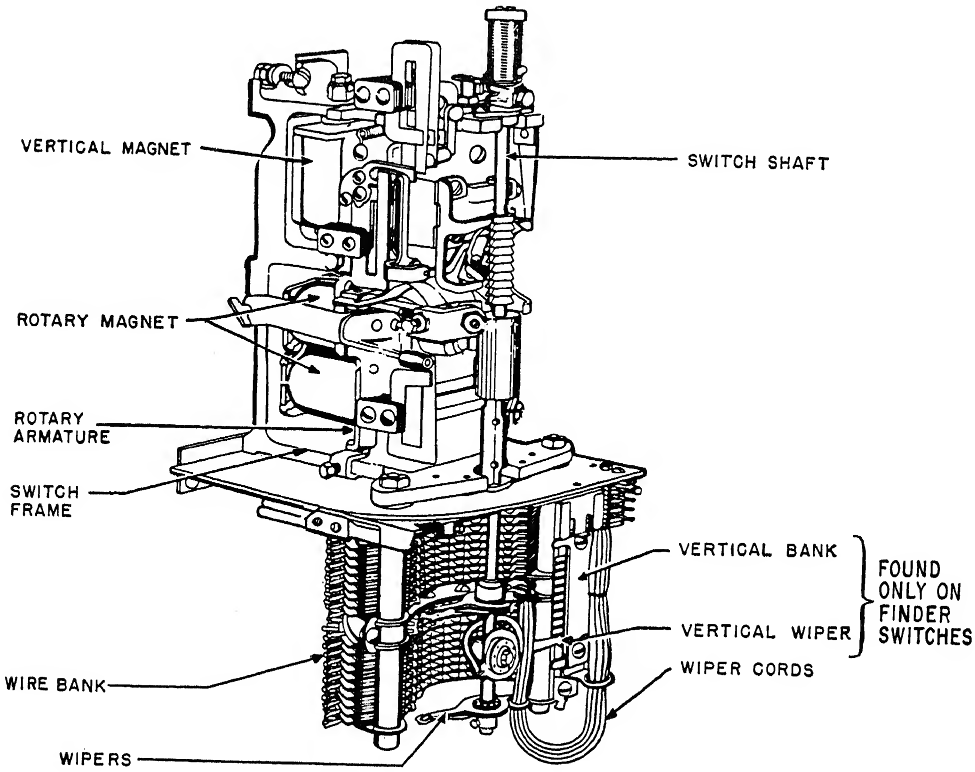


Figure 10-17.—Strowger switch. 140.129

to as a NUMERICAL type Strowger switch because it operates under the control of dial impulses.

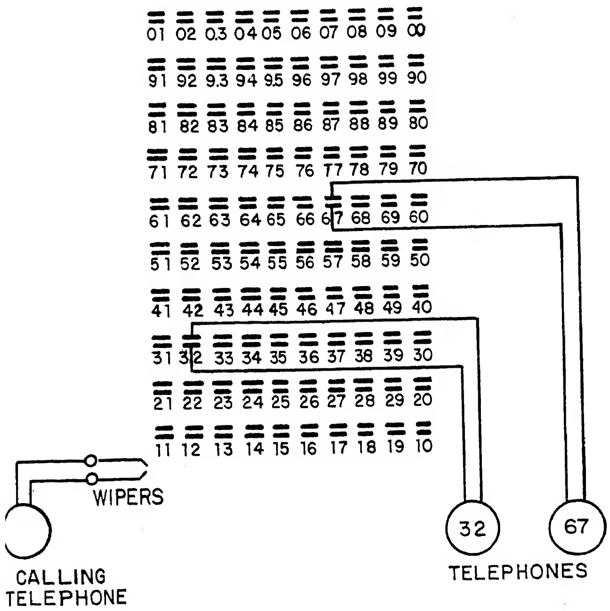
For simplicity, only 3 of the 100 telephones with their associated connector switches are shown in figure 10-19.

Telephone 32 is connected to the wipers of connector 32. Telephone 32 also has an appearance in the bank of each connector—that is, it is multiplied to contact 32 in all of the connector banks. Telephone 67 terminates in wiper connector 67 and is likewise multiplied to its associated contact 67 in all of the connector banks. This multiple arrangement of the connector banks permits any telephone to call any other telephone in the system.

For example, to call telephone 89 from telephone 32, remove the handset from the cradle at telephone 32 and dial the digits 8 and 9. When 8 is dialed, the wipers of the connector switch 32 step up to the eighth level and when 9 is dialed, the wipers rotate into the bank and come to rest on the ninth contact of that level. This action completes the connection to telephone 89.

LINE FINDING.—The 100-line connector system described with reference to figure 10-19 requires an individual connector switch for each line in this system. As the connector is a relatively expensive switch, this system is not economical because the average telephone is used to make calls only a short time each day with the result that the corresponding connector switch remains idle during the remainder of the time.

Line finding permits service to a large group of lines by a smaller number of switches used in common by all lines in the group. The line finding principle is illustrated in the diagram of the two switches shown in figure 10-20.



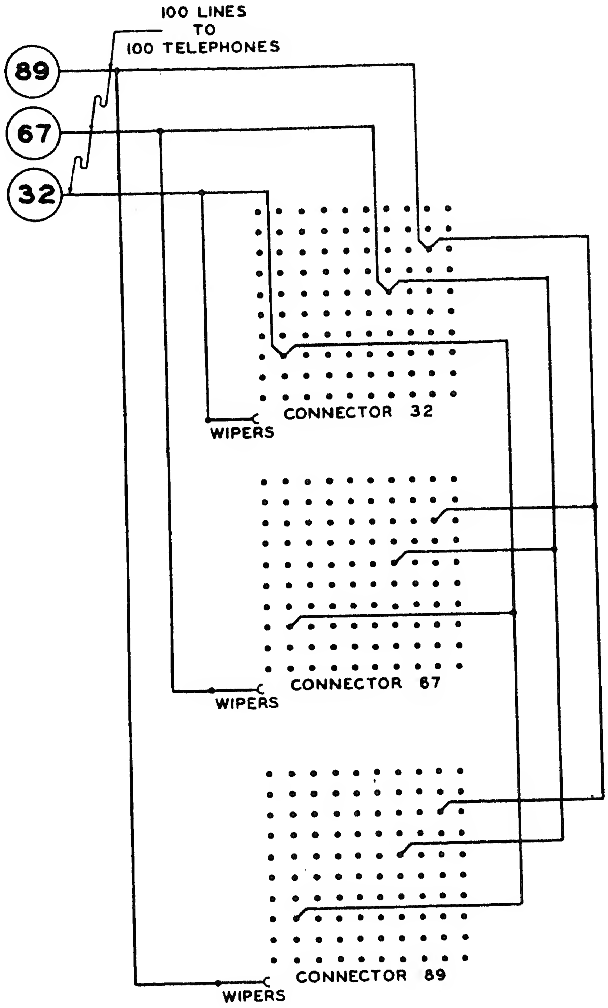
7.77(27C)

Figure 10-18.—Wire bank numbering.

One is called the FINDER SWITCH and the other is the previously mentioned CONNECTOR SWITCH. One finder bank with its wipers and the mechanism necessary to step the wipers up and in constitute a FINDER SWITCH. A finder switch is referred to as a NONNUMERICAL type Strowger switch because its operation is automatic and not under the control of dial impulses. Although four telephones are shown, actually there are 100 telephones connected to the finder bank.

To call telephone 00 from telephone 11, remove the handset from the cradle at telephone 11. The finder switch (fig. 10-20) automatically steps its wipers up to the first level and rotates one step in, stopping on contact 11. Thus the calling telephone is extended through to the wipers of the connector switch. When the digits 0 and 0 are dialed, the wipers of the connector switch step up to the tenth level and rotate 10 steps in, completing the connection between telephones 11 and 00.

BASIC 100-LINE FINDER-CONNECTION SYSTEM.—The system described with reference to figure 10-20 is equipped with one finder switch and one connector switch. Hence, only one conversation is possible at any one time because each conversation requires one finder and one connector to complete and hold a connection between the calling and the called telephones.



7.78(27C)

Figure 10-19.—Basic 100-line system.

The 100-line finder-connector system is shown in figure 10-21A. Each finder switch is permanently tied stem to stern with a connector switch. In other words, the finder faces backward ready to find any line that originates a call, whereas the connector faces forward ready to connect to the dialed line. Such a combination

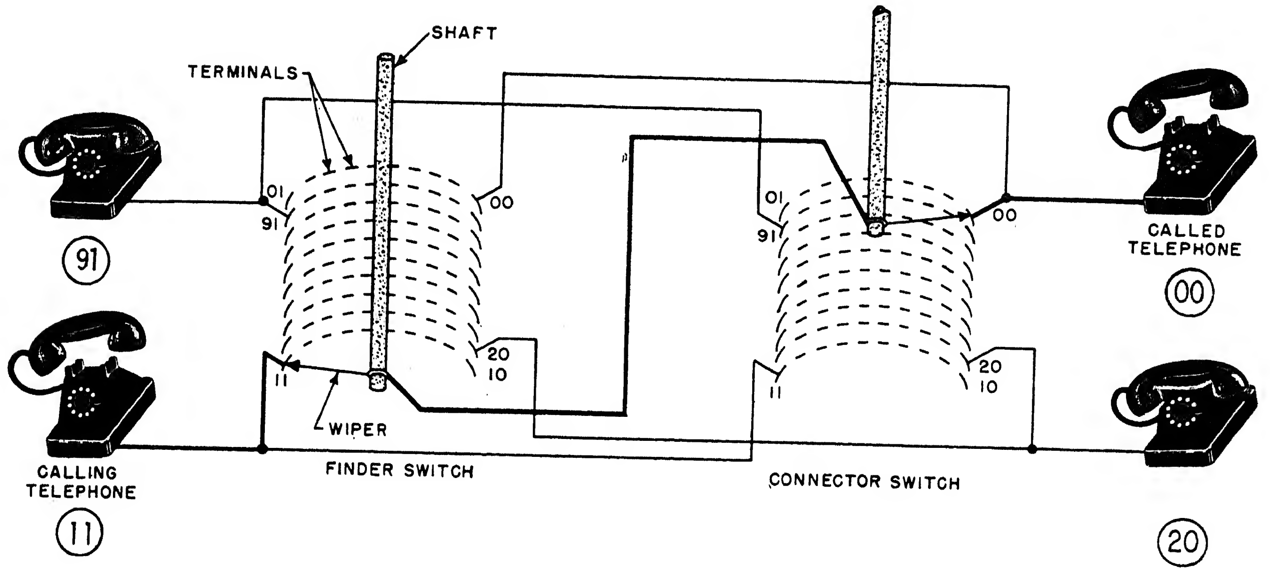


Figure 10-20.—Basic 100-line finder-connector system. 7.78(140B)

of finder and connector is called a FINDER-CONNECTOR LINK. One finder-connector link is required for each of the conversations that are to be held simultaneously. There are 15 finder-connector links in the 100-line Automatic Electric Telephone System.

Each of the 100 lines is connected to each finder bank. Hence, any idle finder is capable of stepping up and rotating in to locate any one of the 100 lines that originates a call. Also, each of the 100 lines is connected to each connector wire bank. Hence, under control of dial impulses from the calling telephone, the connector can step up and rotate in to complete a connection to any one of the 100 telephones.

Look again at figure 10-21A. To call telephone 89 from telephone 32, remove the handset from the cradle at telephone 32. An idle finder such as finder 1, steps up, rotates in, and stops on contact 32. The connection is now extended through to the connector associated with the finder, in this case connector 1, and the dial tone is received by the calling telephone. The DIAL TONE is a signal to the person making the call to dial the number of the called telephone. When digits 8 and 9 are dialed, the wipers of the connector switch step up, rotate in, and stop on contact 89.

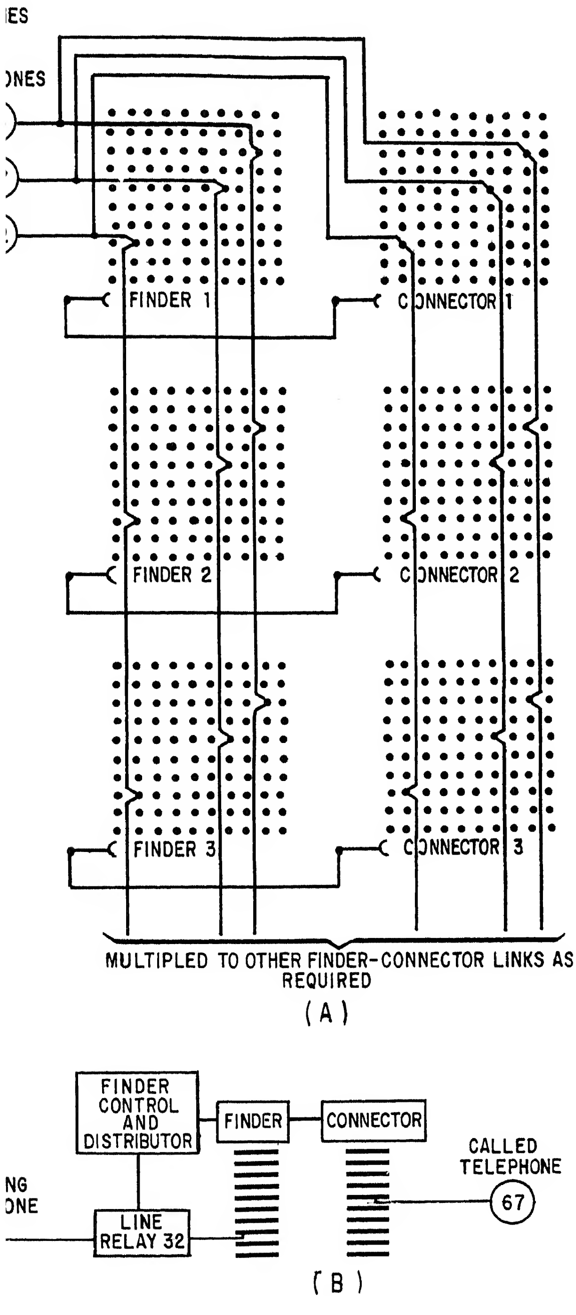
The connection is now completed from telephone 32 through finder-connector link 1 to telephone 89. The connector switch now tests telephone 89 and, if it is not in use, ringing current is sent out to operate the ringer at telephone 89. If telephone 89 is in use, a busy signal is returned to the calling telephone.

A complete 100-line finder-connector system is shown in figure 10-21B. The finder and connector banks are each represented by 10 horizontal lines. The rectangles at the top of the finder and connector banks represent the switch mechanisms. One line relay is associated with each line, whereas the finder control and the distributor equipment is common to all lines.

To call telephone 67 from telephone 32, remove the handset from the cradle at telephone 32. This action closes contacts within telephone 32 which causes line relay 32 to operate. Line relay 32 in operating marks the position of line 32 in the finder banks.

When the line relay operates, it also sends a START SIGNAL to the finder control and distributor equipment which, in turn, starts a preselected idle finder in search of the calling line.

The finder control and distributor equipment at this time automatically preselects the next



7.80(140A)

re 10-21.—Complete 100-line finder-connector system.

finder to have it ready to search for the incoming call.

'he selected finder that is searching for line inds it and extends the connections through e connector switch.

Line relay 32 in operating also makes line 32 busy at the connector banks to guard against intrusion from any incoming call.

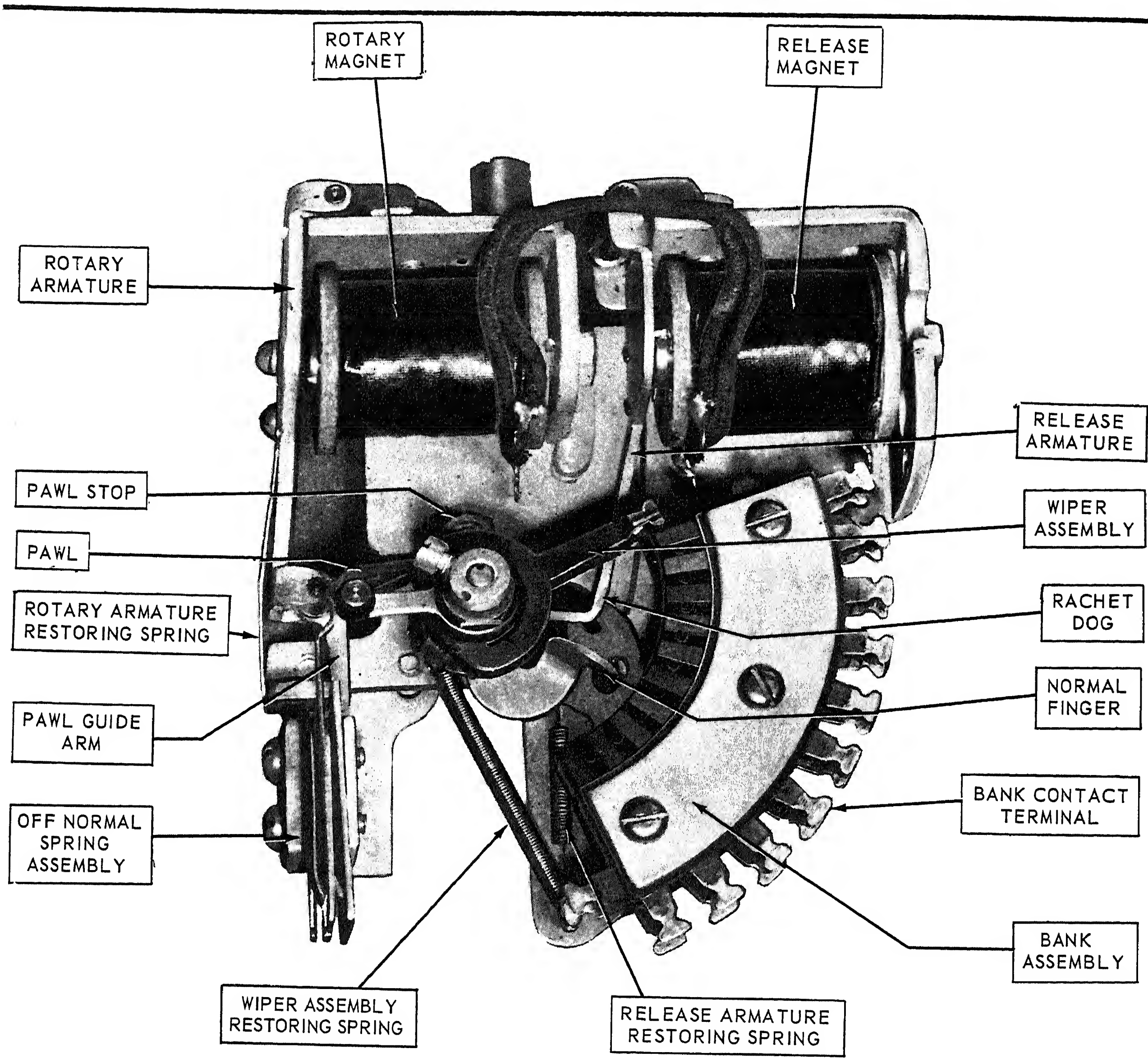
The connector switch returns a dial tone to the calling telephone and the call proceeds as previously explained.

EXPANDING THE 100-LINE SYSTEM.—The 100-line finder-connector system can be expanded to service as many as 200 telephones through the use of a party line system, made possible through the use of an additional switch called a minor switch. The minor switch has rotary motion only and is mounted with the connector switching mechanism. As pictured in figure 10-22 the minor switch bank consists of 10 sets of contacts over which the wipers may step under control of the dial. This switch is a one-function auxiliary switch which rings one or the other of two telephone stations on a two-party line.

With the minor switch arrangement an additional digit is added to all phone numbers. In this type equipment, telephones having the first digit of 1, 2, 3, 4, 5, 6, 7, 8, or 0 will receive ring current over their positive line, while those whose first digit is 9 will receive ring current over their negative line. The arrangement permits the selective ringing of either telephone station of a two-party line. As an example, if you dial number 932, the ringer at telephone station 932, which is connected to operate with negative ring voltage, will operate. The ringer at telephone station 232, which is on the party line with telephone station 932, will not operate because it is connected to operate on positive ringing voltage.

BASIC FINDER-SELECTOR-CONNECTION.—The system described with reference to figure 10-21 has a capacity of 100 lines. In systems of 200 lines or more, a SELECTOR SWITCH is connected between the finder and connector switches, as shown in figure 10-23. The selector is similar in mechanical construction to both the finder and connector. It has a wire bank, wipers, and a two-motion switch mechanism.

The selector faces the called line the same as does the connector. The selector selects the "hundreds" group of lines. From then on, a connector selects both the "tens" group of lines and the "units" line in that group. Note that the lines (fig. 10-23) are divided into groups



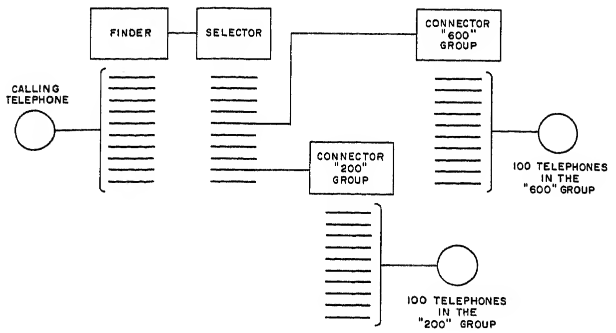
140.76

Figure 10-22.—Minor switch.

of 100. Two such groups are shown, the 200 group with 100 lines and the 600 group with 100 lines. Each group has a corresponding group of connectors which have their banks multiplied together.

Note that each finder switch is tied stem to stern with a selector switch instead of being tied to a connector switch, as in the 100-line capacity system. One finder-selector-connector link is required for each conversation that is to be held simultaneously with other conversations. The connector switch always operates last and selects the "tens" group of lines and the "units" line within the group.

To call telephone 673, remove the handset from the cradle at the calling telephone. An idle



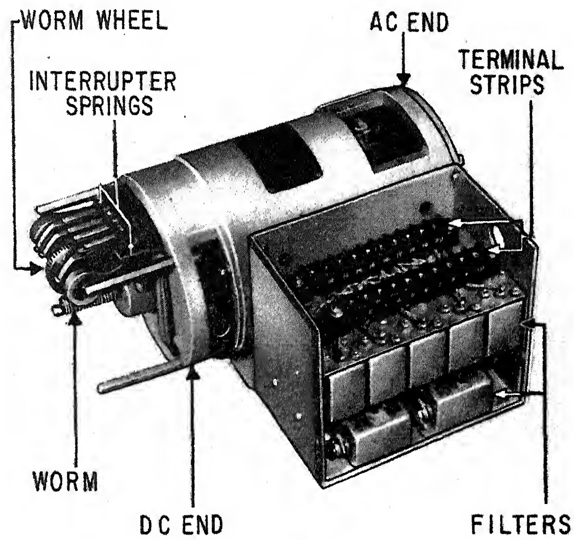
7.82(27C)
Figure 10-23.— Basic selector system.

finder searches and extends the calling line to the selector switch associated with that finder. The selector returns a dial tone to the calling telephone. When the "hundreds"/digit 6 is dialed, the selector wipers step to the sixth level and automatically rotates in to a contact that is attached to an idle connector; this extends the call through to the wipers of a connector. When digits 7 and 3 are dialed, the connector steps up 7 levels and rotates in three steps to complete the call.

ALARM SYSTEM.— The Automatic Electric Dial Telephone switchboard contains an alarm system which warns watch personnel when conditions within the switchboard are not normal. The alarm system consists of a common audible buzzer and lamps that provide a visual indication. Alarms sound if power is lost, if fuses are blown, if problems develop within finders and connectors, or if the handset of telephone stations are left off the hook. Conditions which cause the last two alarms listed usually result in the loss of a finder-connector link which limits the number of simultaneous conversations that the switchboard is capable of handling.

Watch personnel should be alert to immediately correct the conditions that cause an alarm.

RINGING MACHINES.— The Automatic Electric Dial Telephone switchboard contains two ringing machines (fig. 10-24), which are small motor-generator sets. These motor-generator sets produce dial tone, busy tone, and ring and ring-back voltages for the dial telephone system. The second ringing machine provides a backup if the first machine fails.



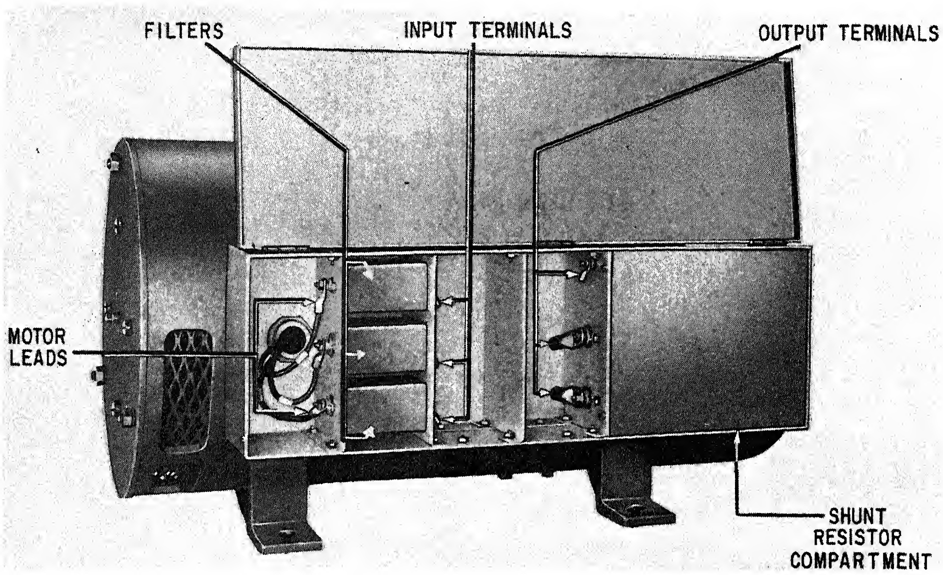
140.82
Figure 10-24.—Ringing machine (covers removed).

POWER EQUIPMENT — The power equipment includes a motor-generator set (fig. 10-25) and a storage battery. The motor-generator set and the storage battery are connected in parallel and supply approximately 51.6-volt d.c. power to operate the automatic switchboard equipment, including the ringing machines and alarm systems. The motor-generator set receives operating power from the ship's 440-volt 60-Hz, 3-phase power supply via the nearest IC switchboard. A reserve supply of energy is maintained in the storage battery so that the telephone system will continue to operate if the ship's power supply fails.

ACCESSORY EQUIPMENT.— The accessory equipment (furnished in some ships) includes an attendant's cabinet (fig. 10-26) which is a small manual switchboard. The attendant's cabinet provides an interface between the ship's telephone system and another telephone system to accomplish calls to and from shore exchanges when the ship is in port, and calls between ships when they are nested.

MARINE DIALMASTER DIAL TELEPHONE SWITCHBOARD EQUIPMENT

The Marine Dialmaster dial telephone switchboard equipment is a relatively recent development. The equipment is modular in construction



140.87

Figure 10-25.—Motor-generator set (cover opened).

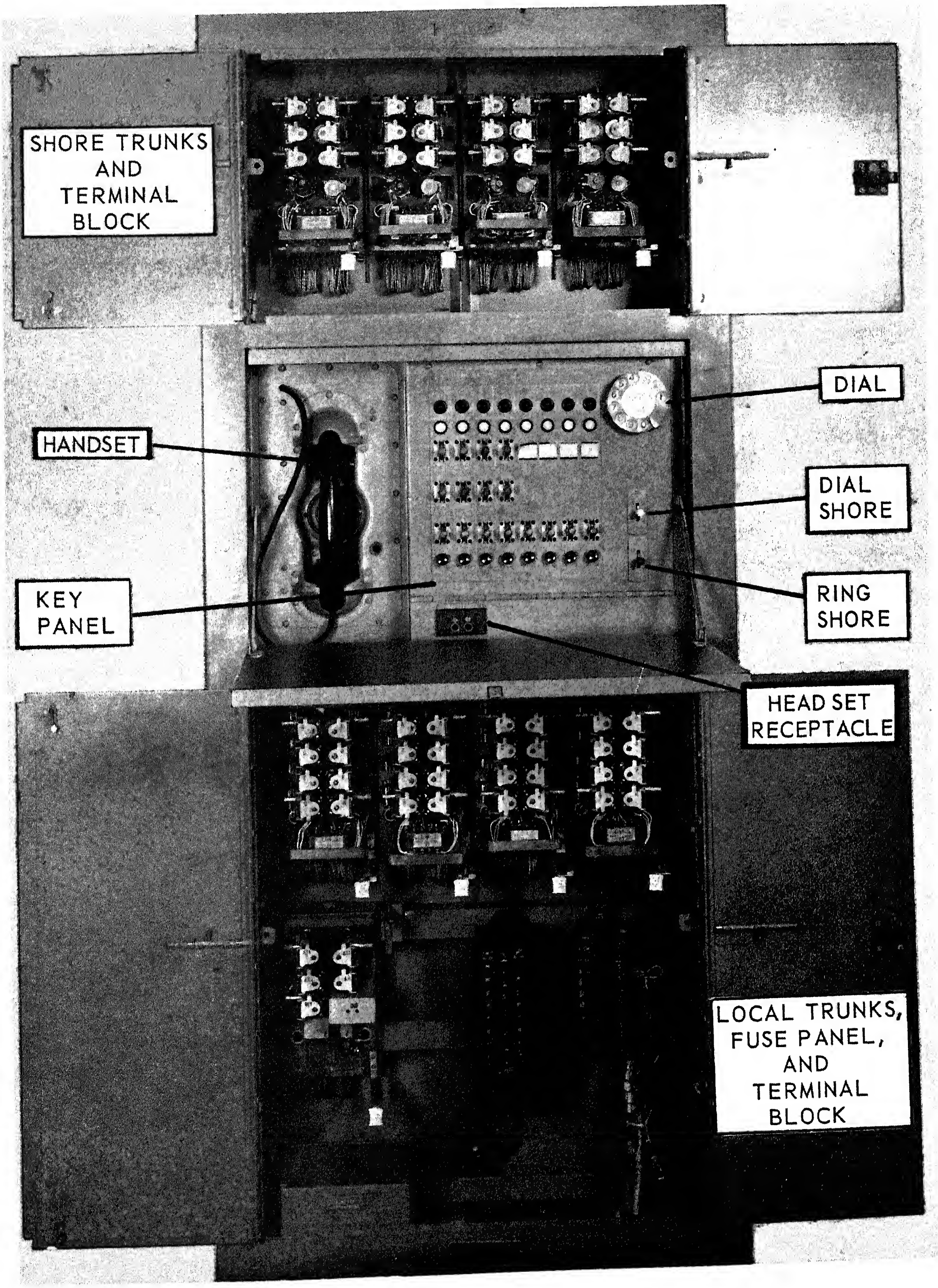
and it is much more compact than the previously discussed Automatic Electric Dial Telephone equipment. For example: the Marine Dialmaster 100-line dial telephone system occupies less than half the space required for an Automatic Electric system with the same capabilities. The compactness of the system is due to modular construction techniques. All electromechanical switching devices and solid-state circuits, as well as all power equipment, are mounted on a single equipment rack. The Marine Dialmaster dial telephone equipment is furnished in two basic systems. One system, the MDM/700, is furnished as a 200-line system capable of being expanded in 100-line increments to a maximum of 700 lines. The other system, the MDM/100-15, is a 100-line system which will be discussed as a comparison to the previously described Automatic Electric 100-line system.

The MDM/100-15 dial telephone system performs the same basic function as the previously described Automatic Electric System. The primary difference is that the MDM/100-15 system employs XY-Universal switches to perform the functions that the Strowger switch performs in the Automatic Electric System. The system is comprised of one switchboard cabinet and in some cases an attendant's cabinet. The MDM/100-15 system can be used with the type A, C, F, or G telephone station equipment.

MDM/100-15
Switchboard

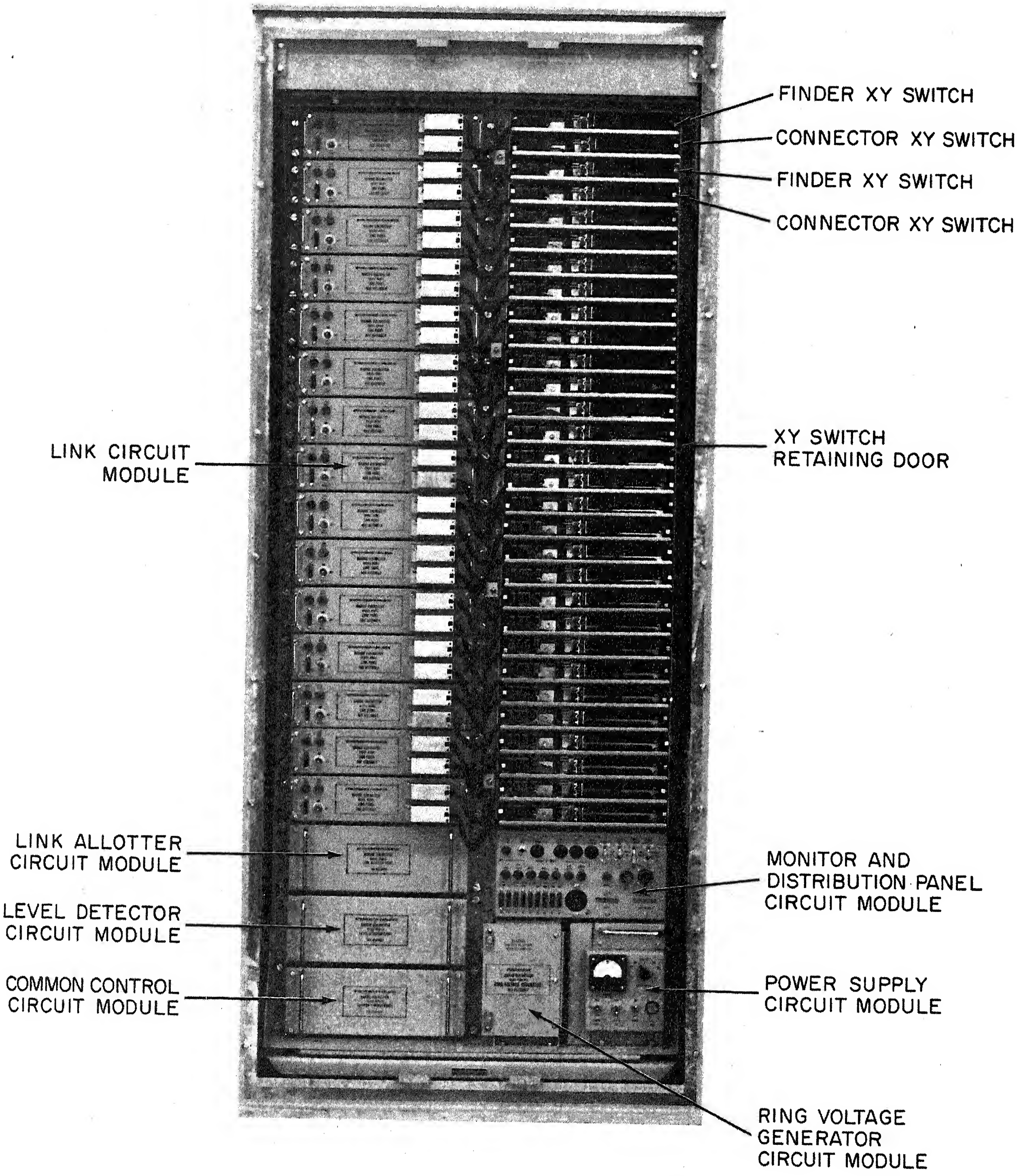
The switchboard consists of one rack of equipment shock-mounted in a rigid cabinet assembly. The cabinet circuit modules, which are accessible through front and rear doors, plug into the frame-jack panel and contain all the switching circuits necessary to operate the system. Two XY-Universal switches are associated with each of the 15 link circuit modules. These switches are mounted in cells on the front of the frame, and they plug into the associated link circuit modules (fig. 10-27). The line connection panels, mounted directly on the switchboard frame (fig. 10-28), provide the means to connect the switchboard to the ship's telephone station cables.

SWITCH COMPONENTS.—In the MDM/100-15 system, the XY-Universal switch (fig. 10-29) functions as a finder and as a connector and provides the means to establish connections from the calling telephone station to the called telephone station. The XY-Universal switch is a two-motion, remote-control device which may be operated under the control of a dial or automatically pulsed from associated control circuitry.



140.79

Figure 10-26.—Attendant's cabinet.



27.391X

Figure 10-27.—MDM/100-15 switchboard cabinet, front view.

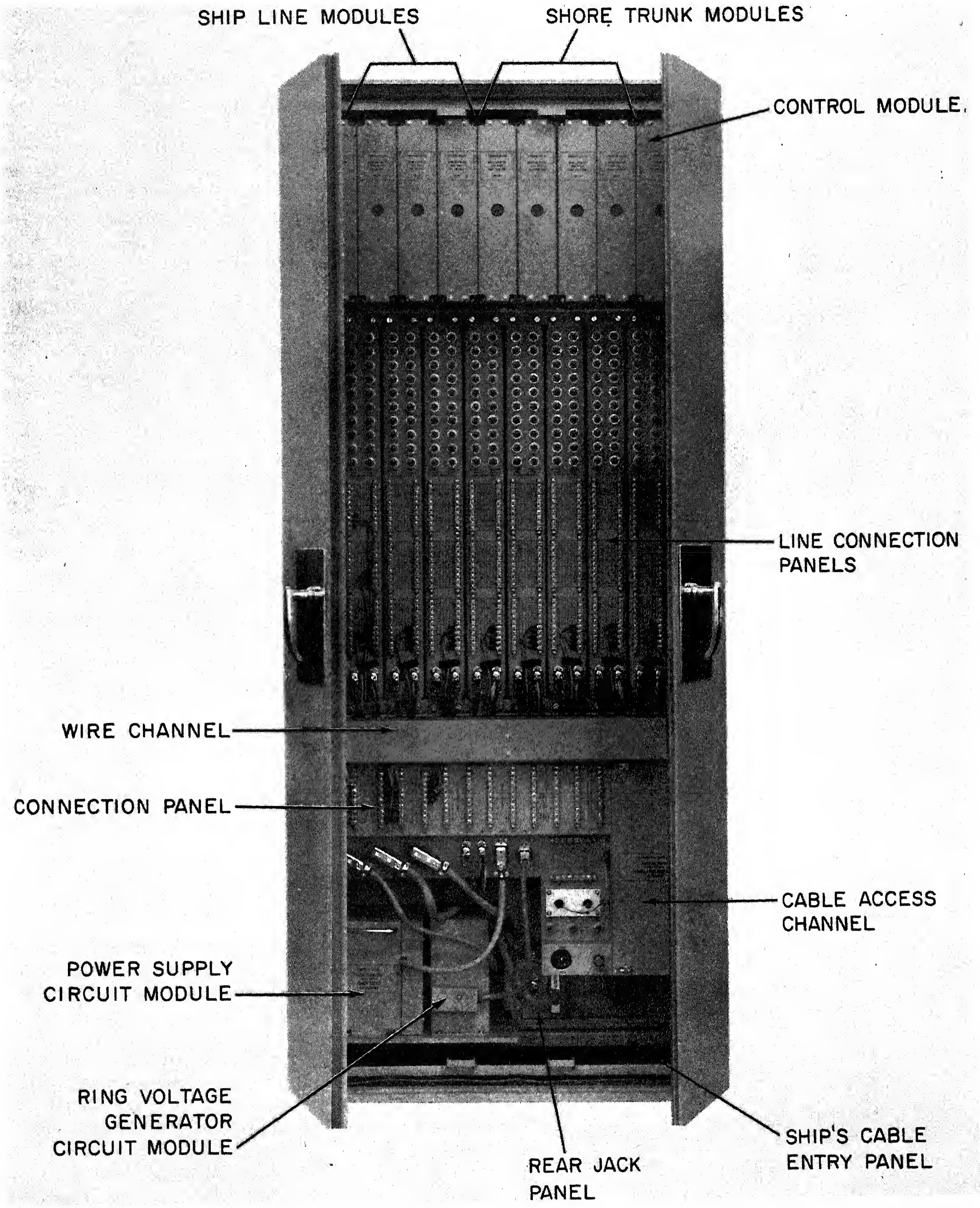


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Figure 10-28. — Switchboard cabinet, rear view.

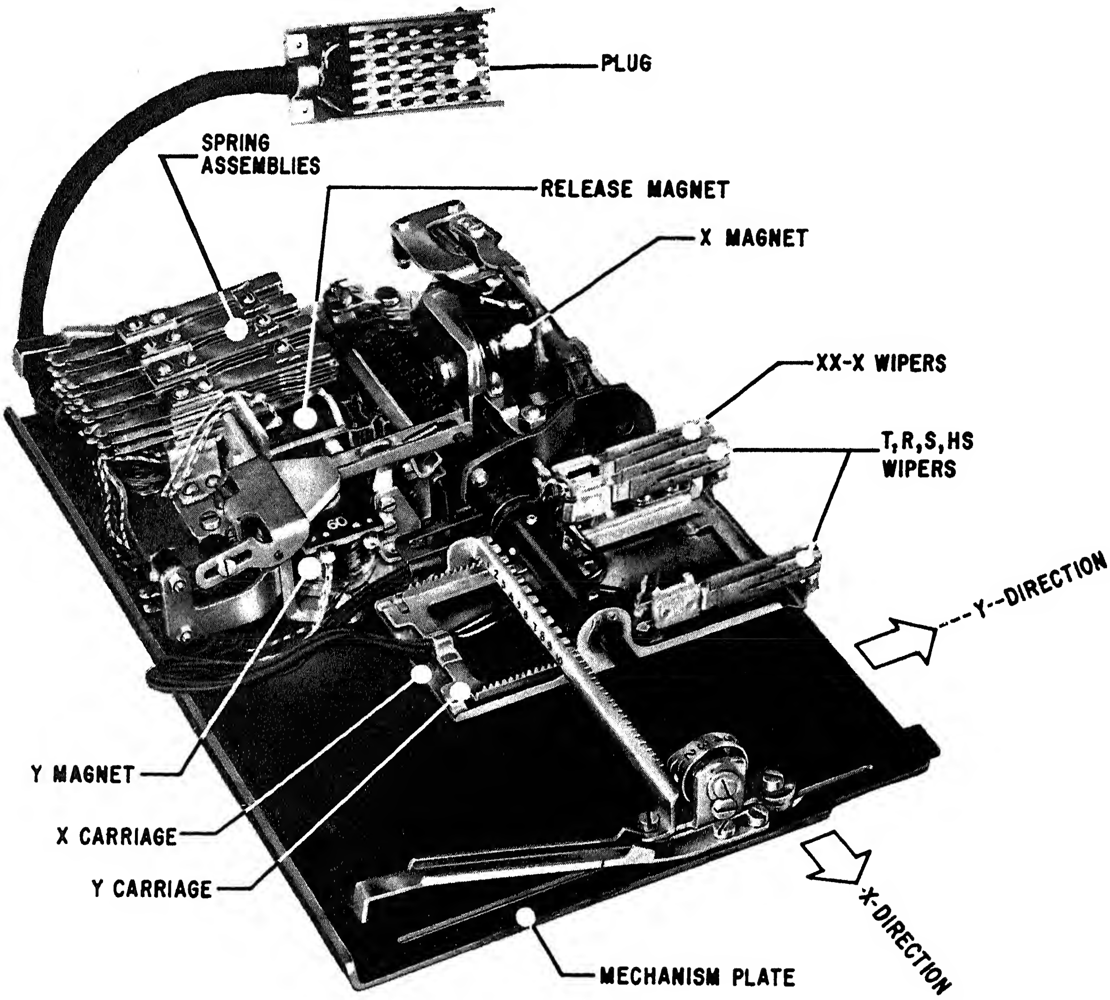

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Figure 10-29.—XY-Universal switch.

The XY-Universal switch can make electrical contact with any of 100 sets of contacts, taking two motions to accomplish the connection. The switch is mounted in a horizontal plane. The switch carriage moves first in the X-direction (left to right parallel to the wire bank) and then in the Y-direction (into the wire bank). When mounted in the switchboard, the XY-Universal switch is located adjacent to a wire matrix, or wire bank. The wire bank runs the length of the switchboard and serves as the contacts for the wipers of all 30 XY-Universal switches in the system.

The XY-Universal Switch.—The main components of the XY-Universal switch (fig. 10-29) are an X-stepping magnet, a Y-stepping magnet, a release magnet, spring pileups, and associated mechanical drive hardware. The switch steps first in the X-direction, controlled by a series of pulses extended to the X-stepping magnet. Each time the magnet operates, the wipers advance one step in the X-direction. The Y-stepping magnet functions in a similar manner to drive the wipers in the Y-direction, which is into the wire bank.

There are 30 XY-Universal switches used in the MDM/100-15 system, 15 as finders and 15 as connectors.

The Wire Bank.—The wire bank associated with the XY-Universal switch is actually made

up of six smaller wire banks: four 10 by 10 wire banks and two 1 by 10 wire banks. The 10 by 10 wire banks are used with the four wires associated with each telephone line. These four wires are the tip (T) and ring (R) for transmission, and the sleeve (S) and helping sleeve (HS) for supervisory and switching. The 1- and 10-wire banks (XX and X) indicate electrically the X-position of the wipers when the wipers are stepped in the X-direction. Each of these banks is associated with its own particular wiper on the XY-Universal switch; hence, the switch wipers are referred to as the T, R, S, HS, and XX-X wipers or banks. Figure 10-30 is a simplified diagram of a 10 by 10 wire bank (as seen from above) with its associated wiper.

The wire banks run the length of the switchboard and are associated with the same wiper for each of the other 30 XY-Universal switches in the system (fig. 10-31). The X-motion of the switch locates the wiper at a position (or bank) opposite the proper section of the wire bank. The Y-motion of the switch positions the wiper into the bank to establish the connection at the proper point.

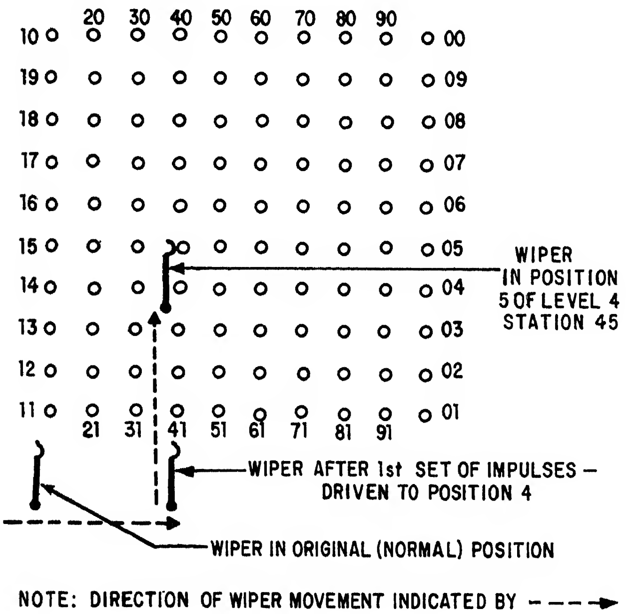

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Figure 10-30.— Wire bank and associated XY-Universal switch wiper, simplified diagram.

FINDER-CONNECTOR LINKS.—As previously stated, the MDM/100-15 system contains 30 XY-switches, 15 as finders and 15 as connectors. These finders and connectors are connected back to back, the same as the finders and connectors of the Automatic Electric System, through 15 link circuit modules as shown in figure 10-27. The link circuit module ties the linefinder and connector together and provides control functions for both switches. The linefinder XY-Universal switch, connector XY-Universal switch, line circuit module, and their portion of the common wire bank comprise one finder-connector link.

Link Allotter.— The link allotter performs the same function in the MDM/100-15 as the finder distributor of the Automatic Electric System — assigns the next idle finder-connector link to the calling party.

System Operation

Basically, the operation of the MDM/100-15 is very similar to that of the Automatic Electric System. Assume that telephone station 12 initiates a call to telephone station 95. When the calling telephone's handset is removed from the hookswitch of telephone 12, a signal is produced that causes the allotter to assign an idle finder-connector link to the calling telephone. As soon as an idle link is assigned, the finder of that link begins to search for the calling telephone line. In this case the finder XY-Universal switch will move 1 step in the X-direction and 2 steps in the Y-direction and the dial tone will return to the calling telephone station at this time. The number of digits that the calling party must dial depends on whether the system is set up to provide party line ringing (negative and positive ringing voltage). If party ringing is to be used, three digits are required, if not, only two digits are required. Let us assume that we are calling telephone 95 and that party ringing will not be used. Therefore, it is necessary to dial only two digits to reach the called telephone station. When the digits 9 and 5 are dialed at the calling telephone, the connector XY-Universal switch steps 9 spaces in the X-direction and 5 spaces in the Y-direction. A busy test is then performed on line 95. If the line is busy, the busy tone will be returned to the calling telephone station. If the line is

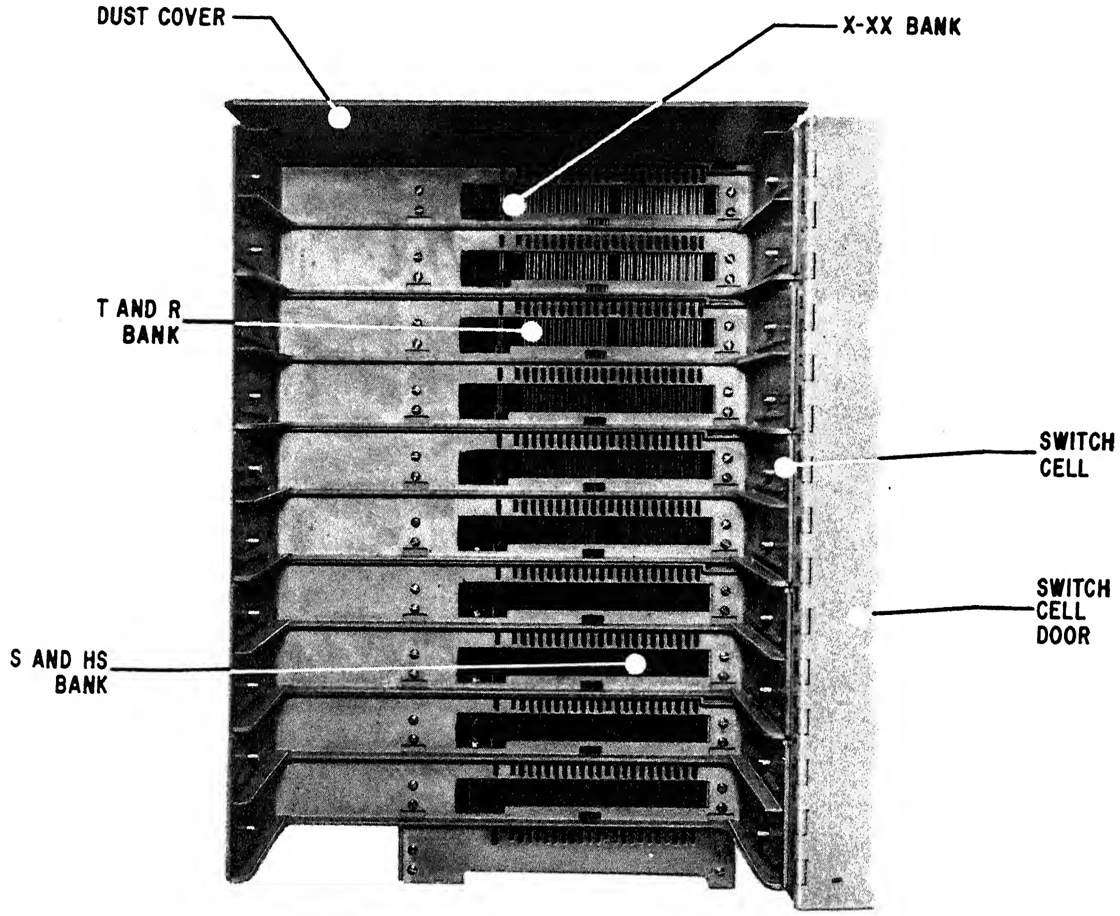

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Figure 10-31.—XY-Universal switch cell and wire banks.

not busy, ringing will be extended to signal the called party.

Power and Signaling Equipment

The MDM/100-15 utilizes solid-state devices to provide its d.c. and ringing voltages. These devices are contained within the switchboard cabinet.

Attendant's Cabinet

The MDM/100-15 installations may be equipped with attendant's switching circuitry to provide attendant-assisted ship-to-shore communications. This circuitry is mounted in the switchboard cabinet (fig. 10-28) and consists of four ship line modules (one for each ship line), four shore line modules (one for each shore line), and one control module. The attendant's switching circuit is controlled from a remotely located attendant's cabinet (fig. 10-32).

Since all of the attendant's switching equipment is mounted in the switchboard cabinet, the attendant's cabinet performs only the functions of a standard telephone with pushbutton control of switching modules to seize and interconnect ship lines and shore lines. The attendant's cabinet is not much larger than a standard type-G telephone set and can be mounted on a desk or bulkhead, or flush-mounted in a suitable panel.

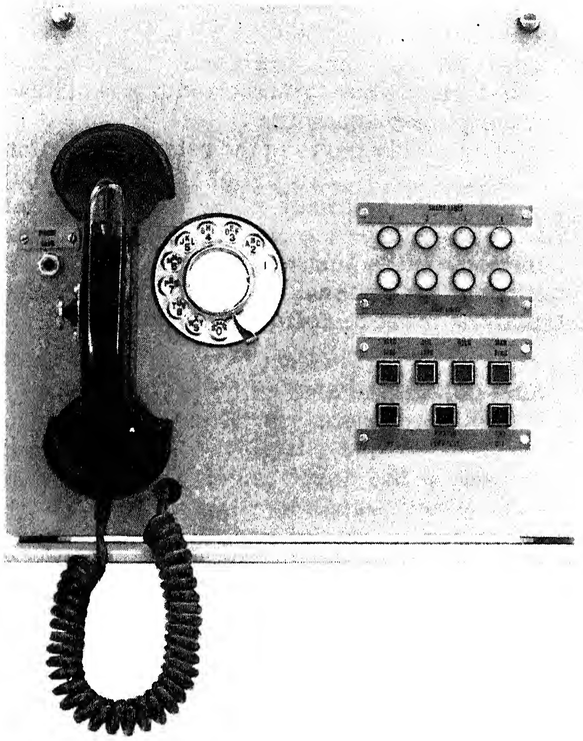

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Figure 10-32.—Attendant's cabinet.

TYPES OF CALLS

Most of the shipboard dial telephone systems are designed to permit a wide variety of telephone calls to meet a variety of needs. These types of calls are summarized below.

Regular local service is the routine call wherein the caller dials the desired number and receives either a ring-back or a busy tone in his receiver. If the called station is manned and if the phone is not in use, the call should be completed. If a busy tone is received, the calling phone must redial the number.

Executive service is that additional feature by which a priority telephone will cut in on a connection which has already been made to the number which he wishes to reach. An executive phone always reaches the party called, even when the line is busy.

Emergency service is a specifically designed feature by which any caller, who dials a special number (usually 211), will reach the station at which the Officer of the Deck has posted his watch, whether the Quarterdeck or the Pilothouse. The call will be completed regardless of whether the line is open or busy. A switch controlling the recipient phone (Quarterdeck or Pilothouse) is located on the telephone switchboard.

Ship to Shore Call is a call connected manually through the attendant's cabinet. To complete this call (possible only when in port and connected), the caller dials the attendant's cabinet, and the ship's operator extends the call through to the shore facility.

Shore to Ship Call is also a feature conducted through the attendant's cabinet. Here again, the ship's operator completes the call through the manual facilities available to him at his station. On many installations ship's telephone lines 37, 38, 39, and 30 are reserved for the manual switchboard.

Additionally, the "hunt the not-busy feature" is employed in cases where a series of numbers serve the same location. In this type arrangement, as in the case of the attendant's cabinet, assume that line 37 is in use and a second caller dials the attendant's cabinet number 37. The call will be shifted automatically to line 38. This "hunt" feature continues until the call is completed or until the caller receives busy from the last in the series of so connected lines (30).

SAFETY

Potentials as high as 450 VAC may be encountered while your men work on dial telephone equipment. Your men must practice all standard precautions when working around high voltages, rotating machinery, and batteries.

An additional precaution for dial telephone systems that you should observe is that all shore telephone lines must be connected to a lightning arrestor box located on the weather decks before the line is routed to the telephone equipment. The lightning arrestor box protects the telephone operator and the telephone equipment in case lightning should strike the incoming telephone lines.

DIAL TELEPHONE SYSTEM MAINTENANCE

Aboard ship, every attempt should be made to maintain a telephone school graduate with an NEC for the type of system installed. However, this is not always possible and should not be used as an excuse to let the system deteriorate.

The knowledge necessary to operate and maintain this system can be obtained from a combination of PQS, OJT, and the manufacturer's technical manual.

Dial telephone system maintenance includes periodic tests and inspections, lubrication, cleaning, troubleshooting, and repair. Test equipment, special tools, special lubricants, and charts are provided with each system, and detailed maintenance instructions are included in PMS and the manufacturer's technical manual.

Cleanliness is essential because of the low voltages and currents involved. Dirt and dust can cause insulation failures and high resistance or partially open contacts.

The adjustable parts of the relays and switches are delicate and require the use of special adjustment tools. Adjustment of a switch or relay should not be attempted until it has been definitely determined that adjustment is necessary. When adjustment is necessary, the manufacturer's instructions must be followed carefully.

CHAPTER 11

AMPLIFIED VOICE SYSTEMS

Many types of voice communication facilities are needed to effectively control and administer a naval vessel during the course of each day. The telephone systems, described in the previous chapters, fulfill many of these needs, but their effectiveness is limited in high noise level areas and where it is desired to transmit a command or information to several listeners simultaneously. Amplified voice systems are used to overcome some of the shortcomings of telephone systems.

Amplified voice systems are used in a wide variety of forms aboard Navy ships such as public address and intercommunication (intercom) systems. Other variations of amplified voice systems that are employed are tape recorders, sound motion picture projection equipment, and ship's entertainment equipment.

ANNOUNCING AND INTERCOMMUNICATING SYSTEMS

The general purpose of shipboard announcing and intercom systems, circuits 1MC through 59MC, is to transmit orders and information between stations within the ship by amplified voice communication—by either a central amplifier system, or an intercommunication system. A central amplifier system is used to broadcast orders or information simultaneously to a number of stations. An intercom system is used for two-way transmission of orders or information.

Each announcing and intercom system installed aboard ship is assigned an IC circuit designation in the MC series. The Chief of Naval Operations authorizes these MC circuits for each class of vessel, based on size, complement, function, and operational employment. Authorized IC announcing circuits are listed in Table 11-1, according to importance and readiness. These systems, however, are not all installed in any one ship.

CENTRAL AMPLIFIER ANNOUNCING SYSTEMS

Central amplifier announcing systems are designed to furnish amplified voice communication and, in some cases, alarm signals to the various loudspeakers located throughout the ship. These systems transmit the spoken word or signal from a station, amplify the signal at a central amplifier, and radiate the signal from the loudspeaker or loudspeakers located in remote areas.

As you can see in table 11-1, several of the MC systems are of the central amplifier type. The size of these systems ranges from the 1MC system on an aircraft carrier to the very small by comparison, 29MC system on an old class destroyer. In many instances, the control and amplification facilities of several different MC systems may be combined. As an example: if a ship has a 6MC system installed, it is usually combined with the 1MC system.

1MC-6MC Announcing Systems Equipment

The combined 1MC-6MC systems installation provides general shipboard announcing (circuit 1MC) and intership announcing (circuit 6MC) facilities. Additionally, a means of broadcasting various ship's alarms is provided in conjunction with, and as part of, circuit 1MC. The typical 1MC-6MC installation consists of: alarm contact makers, microphone control stations, loudspeakers, visual alarm indicators and the control/ amplifier equipment. Figure 11-1 is a block

Table 11-1.—Shipboard Announcing Systems

Circuit	System	Importance	Readiness Class
*1MC	General	V	1
*2MC	Propulsion plant	V	1
*3MC	Aviators'	V	1
4MC	Damage Control	V	1
*5MC	Flight Deck	SV	2
*6MC	Intership	SV	1
7MC	Submarine Control	V	1
8MC	Troop administration and control	SV	2
*9MC	Underwater troop communication	SV	2
*10MC	Dock Control (obsolete)	SV	1
*11-16MC	Turret (obsolescent)	SV	3
*17MC	Double Purpose Battery (obsolescent)	SV	3
18MC	Bridge	NV	2
19MC	Aviation Control	SV	2
*20MC	Combat Information (obsolescent)	SV	1
21MC	Captain's Command	SV	1
22MC	Electronic Control	NV	1
23MC	Electrical control	SV	1
24MC	Flag Command	SV	1
25MC	Ward Room (obsolescent)	NV	4
26MC	Machinery Control	SV	1
27MC	Sonar and Radar Control	SV	1
*28MC	Squadron (obsolescent)	NV	4
*29MC	Sonar Control and Information	SV	2
30MC	Special Weapons	SV	2
31MC	Escape trunk	SV	2
32MC	Weapons control	SV	3
33MC	Gunnery Control (obsolescent)	SV	3
34MC	Lifeboat (obsolescent)	SV	1
35MC	Launcher Captains'	SV	1
36MC	Cable Control (obsolete)	NV	4
37MC	Special Navigation (osbolete)	SV	2
38MC	Electrical (obsolete)	NV	1
39MC	Cargo Handling	NV	4
40MC	Flag Administrative	NV	1
41MC	Missile Control and Announce (obsolete)	SV	3
42MC	CIC Coordinating	SV	2
43MC	Unassigned		
44MC	Instrumentation Space	NV	1
45MC	Research operations	NV	1
*46MC	Aviation Ordnance and Missile Handling	SV	2
47MC	Torpedo Control	SV	2
48MC	Stores conveyor (obsolescent)	NV	1
49MC	Unassigned		
50MC	Integrated operational intelligence center	SV	2

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Table 11-1.—Shipboard Announcing Systems—continued

Circuit	System	Importance	Readiness Class
51MC	Aircraft Maintenance and handling control	SV	2
52MC	Unassigned		
53MC	Ship Administrative	NV	4
54MC	Repair Officer's Control	NV	4
55MC	Sonar Service	NV	4
56MC	Unassigned		
57MC	Unassigned		
58MC	Hanger Deck Damage Control	V	1
59MC	SAMID Alert	SV	3

Legend:
* = Central amplifier systems
V = Vital
SV = Semivital
NV = Nonvital

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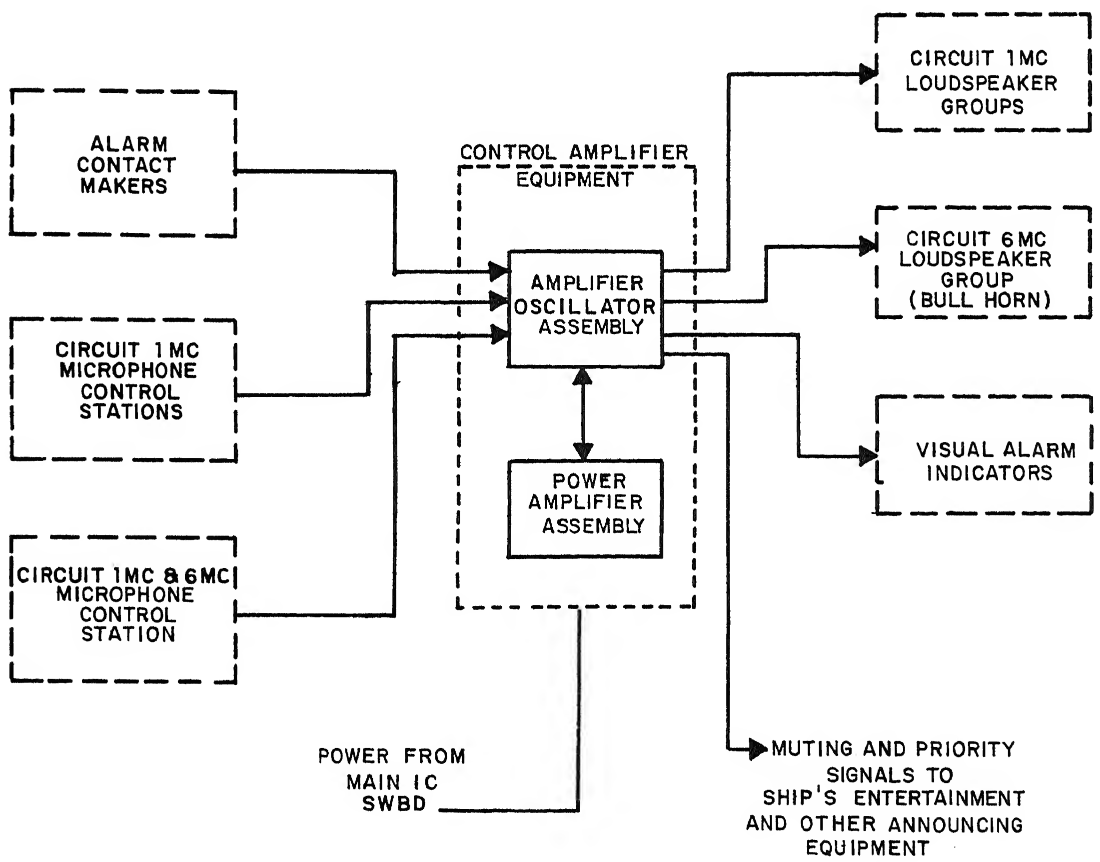

Figure 11-1.—Typical 1MC-6MC systems installation. 140.125

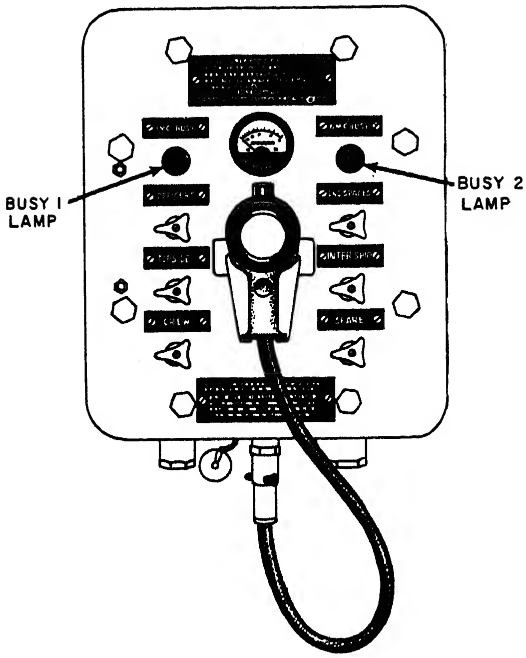

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Figure 11-2.—1MC-6MC microphone control station.

diagram of a typical 1MC-6MC systems installation found aboard a destroyer. Power for operating the system is obtained from the 120-V 60-Hz distribution section of the main IC switchboard.

ALARMS AND ALARM CONTACT MAKERS.—A number of different alarms may be generated within and broadcast over circuit 1MC. The nature and number of alarms is dependent to some extent on the mission of the ship aboard which the system is installed. As a rule, however, all 1MC systems installed aboard surface ships are capable of generating and broadcasting collision alarms, chemical attack alarms, and general alarms. The alarms are generated by oscillators located within the control/amplifier equipment. Alarms are activated by closing a lever-operated switch type contact maker (described in chapter 8). Each alarm that is generated and broadcast by the system has at least one of its own contact makers, i.e., the general alarm is actuated by a general alarm contact maker, the collision alarm is actuated by a collision alarm contact maker, etc. The alarm contact makers are installed at various locations such as the bridge and quarterdecks where they are easily accessible to watchstanders.

The alarms are broadcast over circuit 1MC only and they have priority over 1MC voice transmissions. Additionally, a system of priorities is part of the alarms. The order of alarm priorities is (1) collision alarm, (2) chemical attack alarm and (3) general alarm. If a low priority alarm is being sounded and the contact maker for a higher priority alarm is closed, the lower priority alarm will be silenced and the higher priority alarm will be transmitted over the 1MC loudspeakers. Conversely, the closure of a low priority alarm contact maker has no effect on a high priority alarm that is being sounded.

MICROPHONE CONTROL STATIONS.—Microphone control stations (fig. 11-2) provide the facilities to make voice announcements over the 1MC or 6MC system and to select the loudspeakers over which the voice announcements will be broadcast. The microphone control station consists of a microphone with a press-to-talk switch, loudspeaker group selector switches, busy lamps, and a signal level meter.

To make a voice transmission from a microphone control station, first, depress the loudspeaker group selector switches (crew, officer, engineers, etc.) over which you desire to make the transmission. Next, depress the press-to-talk switch and speak into the microphone with sufficient force to cause the deflections of the signal level meter pointer to peak at midscale. The busy lamps indicate that a transmission is in progress from another microphone control station.

Ships usually have at least two microphone control stations. The bridge is equipped with a 1MC-6MC microphone control station and the quarterdeck is equipped with a 1MC only microphone control station, which does not have an intership loudspeaker (6MC) selector switch. The microphone control stations are also under a system of priorities as are the alarms. Bridge 1MC transmissions have priority over the quarterdeck 1MC transmissions. Under certain conditions, which will be discussed later in this chapter, the 1MC has priority over the 6MC.

LOUDSPEAKERS AND LOUDSPEAKER GROUPS.—Loudspeakers convert the amplified voice and alarm electrical signals to sound. Several different types of loudspeakers are used in 1MC-6MC systems to suit different needs. Figure 11-3 illustrates two loudspeaker types.

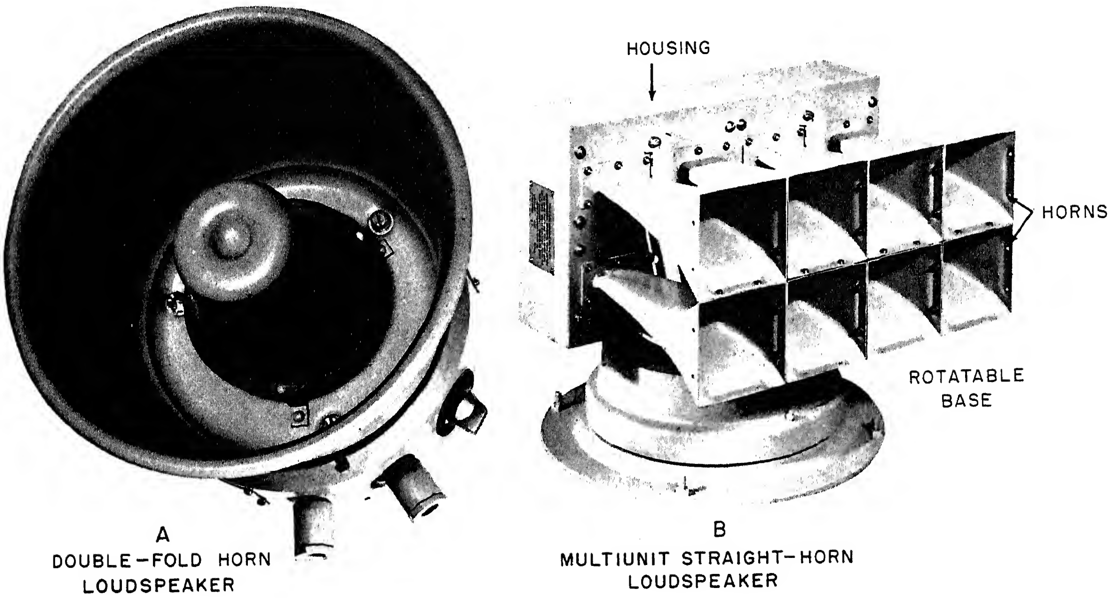

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Figure 11-3.—Dynamic horn loudspeakers.

The double-fold horn is used with circuit 1MC on weather decks or in high noise areas. The multiunit straight-horn (bullhorn) is a high-power unit used for intership (6MC) voice communications.

For purposes of selectivity and damage isolation, the various 1MC loudspeakers are organized into groups and subgroups. A typical destroyer installation consists of four loudspeaker groups—(1) officers, (2) topside, (3) crew, and (4) engineers. A 1MC voice transmission may be made via any one or all of the speakers by selecting the appropriate speaker group or groups at the microphone control station. Since the loudspeakers of the groups are separated into physical zones, i.e., officers' country, engineering spaces, etc., a damaged loudspeaker in a group could result in the complete loss of 1MC transmission to an entire area of the ship. To overcome this handicap, groups are divided into subgroups with an action cutout switching arrangement. The subgroups consist of several loudspeakers from the parent group. Loudspeakers of the subgroup are selected so that not all of the speakers of a space or geographical area belong to a specific subgroup. A damaged loudspeaker of a 1MC system subgroup may be isolated through the action cutout switching arrangement without completely losing 1MC capability to a major space or area.

Usually one or two 6MC loudspeaker units are installed. The 6MC loudspeakers are not divided into groups. The desired 6MC loudspeaker is selected at the bridge microphone control station.

VISUAL ALARM INDICATORS.—Visual alarm indicators consist of lighting fixtures with red lamps installed in machinery spaces where high noise levels are common. The red lamp lights steady when the collision and chemical attack alarms are sounded and flashes when the general alarm is sounded.

CONTROL/AMPLIFIER EQUIPMENT.—The control amplifier equipment is the heart of the 1MC/6MC system. All signals and control functions that are required for system operation are either processed by or developed within it. Control/amplifier equipment:

1. Generates alarm signals of various characteristics when activated by the closure of an alarm contact maker.

2. Amplifies voice and alarm signals to a magnitude sufficient to drive the many loudspeakers of the system.

3. Channels the amplified voice signals to the specific loudspeaker groups as selected at the microphone control station.

4. Channels the ordered alarm signals to all the loudspeaker groups of the system.

5. Provides a backup amplifier and oscillator.

6. Provides facilities to control the volume of voice signals and to monitor, test, and isolate certain components of the system.

7. Performs specific functions in accordance with a built-in set of priorities.

8. Energizes the visual alarm indicators when an alarm is sounded.

The two units of the control/amplifier equipment such as the one illustrated in figure 11-4 contain the oscillators, preamplifiers, power

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Figure 11-4.—AN/SIA-114 control/amplifier equipment.

Table 11-2.—Alarm Signal Characteristics

Signal	Characteristic
Collision Alarm	Triple pulsed 1000 Hertz tone
Chemical Alarm	Continuous 1000 Hertz tone
General Alarm	Gong tone
Unassigned Alarm "A"	500-1500 Hertz jump tone (1 1/2 per sec)
Unassigned Alarm "B"	600-1500 Hertz jump tone (6 per sec)
Flight Crash Alarm	Simulated siren tone

amplifiers, and control devices necessary for the system to perform as stated above.

Oscillators.—The oscillators provide the various alarm signals required for the system. The sound characteristics of each alarm are different so that each may be easily distinguished from the others. The sound characteristics for each alarm have been standardized (table 11-2) on surface craft so that the alarm signals on all ships are identical. Only three alarms—collision, chemical attack, and general—have been mentioned thus far. These three alarm signals may be sufficient for some ships, whereas for other ships additional alarm signals may be required. So that the control/amplifier equipment may be installed on several classes of ships, the oscillators of most equipment are capable of producing other designated alarm signals, such as the flight crash alarm. They are also capable of producing signals that are not designated by name, but are reserved for future use. The oscillators of the equipment shown in figure 11-4 produce two such alarm signals—the unassigned alarm "A" and the unassigned alarm "B." These two alarm signals have their own individual sound characteristics and are reserved for future use as may be directed by higher authority.

The control/amplifier equipment has two oscillator subassemblies which are contained within the amplifier-oscillator assembly. Only one of the two oscillators is required to produce the alarm signals required of the system. A rotary selector switch located on the front panel of the amplifier-oscillator assembly is used to select which oscillator will produce the system alarm signals. The inactive oscillator is then available for maintenance or repair, or to produce signals that may be used to test an inactive preamplifier and power amplifier.

Preamplifier and Power Amplifier.—The preamplifier is contained within the amplifier oscillator assembly. It amplifies the weak voice signals from the microphones and the alarm signals from the oscillators to a value sufficient to drive the power amplifier. To compensate for the different voice levels of system users, the preamplifier contains special circuits which attenuate those high level input signals that would cause overdriving and distortion at the loudspeakers.

The power amplifier is contained in the power amplifier assembly and receives the relatively weak voice signals and alarm signals from the preamplifiers and greatly increases their power level to a level that is sufficient to drive the loudspeakers. The signals from the power amplifier are returned to the amplifier-oscillator assembly for distribution to the different speaker groups.

One preamplifier in conjunction with one power amplifier form one channel. Usually, there are two preamplifiers and two power amplifiers in the 1MC-6MC system connected to form two channels (channel A and channel B). The equipment shown in figure 11-4 contains two amplifier channels each of which is capable of producing 500 watts of audio power.

The two identical amplifier channels are provided to permit independent operation of the 1MC and 6MC systems if desired, one system on each of the two channels. A channel selector switch is provided on the front panel of the

amplifier-oscillator assembly to provide flexibility to the system. The selector switch can be positioned for systems operation as follows:

1. 1MC on channel A, 6MC on channel B
2. 1MC and 6MC on channel A
3. 1MC and 6MC on channel B

The last two combinations may be used to isolate one of the channels for service. The first position listed is used for independent operation of the 1MC and 6MC.

Because a large amount of heat is radiated from the power amplifiers, many ships operate with both systems on the same channel, with the remaining channel secured and in reserve. This mode of operation greatly reduces the radiated heat and resulting insulation deterioration. As the 6MC system is used seldom, as compared to the 1MC system, operating in this manner presents few operational disadvantages. However, it does extend equipment life.

As previously discussed, under certain circumstances the 1MC voice transmissions have priority over 6MC voice transmissions. When the system is operating with the 1MC on amplifier channel A and the 6MC on amplifier channel B, it is possible to broadcast over the 6MC system from the bridge microphone station and, at the same time, to broadcast over the 1MC from the quarterdeck microphone station. When both systems are operated on the same amplifier channel, 1MC transmission takes priority over 6MC transmissions.

1MC-6MC Announcing Systems Operation

The 1MC-6MC system, as stated previously, provides a means of transmitting 1MC alarms, 1MC voice, and 6MC voice. Listed below are basic descriptions of how the systems perform these tasks. The descriptions are general in nature and vary depending on the particular equipment and installation.

1MC ALARM TRANSMISSIONS.— Transmission of a 1MC alarm begins when an alarm contact maker—collision, chemical attack, or general—is closed. Closure of the contact maker energizes a specific relay for that alarm, setting in motion a sequence of events within the control/amplifier equipment which disables the circuitry for other alarms having lower priority and completes the circuits that cause a number of other relays to operate to:

1. Energize the on-service oscillator in such a manner as to cause it to produce the desired sound.
2. Establish priority over 1MC-6MC voice transmissions.
3. Illuminate the busy 1 and busy 2 (1MC busy and 6MC busy) lamps at the microphone control stations to alert personnel that 1MC and 6MC voice transmissions are not possible.
4. Provide a control signal to ship's entertainment and other announcing equipment to mute or disable it.
5. Connect the output of the selected oscillator to the input of the amplifier channel selected for 1MC transmissions.
6. Apply power to the selected amplifier channel.
7. Operate all the loudspeaker group relays so that the alarm signal will be transmitted over all of them.
8. Energize the visual alarm indicators—steady for collision and chemical attack alarm, intermittent for general alarm.

For the collision and chemical attack alarms, the above conditions will continue to exist only as long as the contact maker is closed. Momentary operation of the general alarm contact maker causes the alarm to sound for a predetermined 15-second period.

1MC VOICE TRANSMISSIONS.— Operation of the microphone press-to-talk switch at the microphone control station sets up the following sequence within the control/amplifier equipment.

1. Connects the microphone output to the input of the amplifier channel selected for 1MC transmissions.
2. Causes the loudspeaker group relays to energize for those loudspeaker groups that have been selected at the microphone control station. This action connects the output of the amplifier channel to those loudspeaker groups over which it is desired to transmit the voice information.
3. Energizes the busy lamps on the microphone control stations as follows:
   a. 1MC on channel A and 6MC on channel B: the busy 1 (1MC busy) lamp is illuminated at all microphone control stations.
   b. 1 MC and 6MC on channel A or 1MC and 6MC on channel B: both the busy 1 and busy

2 (1MC and 6MC busy lamps) are illuminated at all microphone control stations.

4. Establishes 1MC priority over the 6MC transmission if both the 1MC and 6MC systems are sharing the same amplifier channel.

5. Sends control signal to the ship's entertainment to mute its transmission.

6. Applies power to the amplifier channel selected for 1MC service.

7. The operator makes his transmission through the microphone, regulating the force of his voice, to cause the pointer of the meter on the microphone control station to peak at midscale deflection.

6MC VOICE TRANSMISSIONS.—6MC voice transmissions are very similar to 1MC voice transmissions. 6MC transmissions differ mainly in that:

1. They can only be made from the bridge or other specifically designated 1MC-6MC microphone control stations.

2. The 6MC loudspeaker is selected as opposed to the 1MC loudspeaker groups.

3. The busy lamps on the microphone control stations are energized as follows:

a. 1MC on channel A and 6MC on channel B: the busy 2 (6MC busy) lamp is illuminated at all microphone control stations.

b. 1MC and 6MC on channel A or 1MC and 6MC on channel B: both busy lamps are illuminated at all microphone control stations.

Maintenance and Safety

Maintenance personnel must be very careful when servicing this equipment. All the common rules of safety and good sense apply, as they would to any other electrical equipment. Special care should be exercised with this equipment, however, because:

1. Voltages in excess of 1,000 volts may be present within the control/amplifier equipment.

2. The sound pressure level emitted from a 6MC loudspeaker (bullhorn) is very high. Transmission should not be made over the 6MC system while personnel are in the vicinity of the loudspeaker.

INTERCOMMUNICATING SYSTEMS

An intercommunicating (intercom) system consists of a number of permanently located stations. Each station contains all the necessary components to provide two-way amplified voice communication, supplemented by signal lamps, between two stations. The units used in intercom systems serve the same purposes and operate basically the same as the commercial intercom units so common in many business offices. Navy and commercial intercom units differ mainly in their physical appearance. The typical intercom systems used aboard naval ships consist of a number of compatible intercom units and their interconnecting cabling.

Intercom Unit

There are several basic types of intercom units in use throughout the Navy, with certain variations to the basic types. These types differ mainly in physical appearance and in the materials used in their construction. Irrespective of their appearance and construction, their electrical characteristics have been standardized to permit intercom units of different manufacturers and construction to be used in one common system.

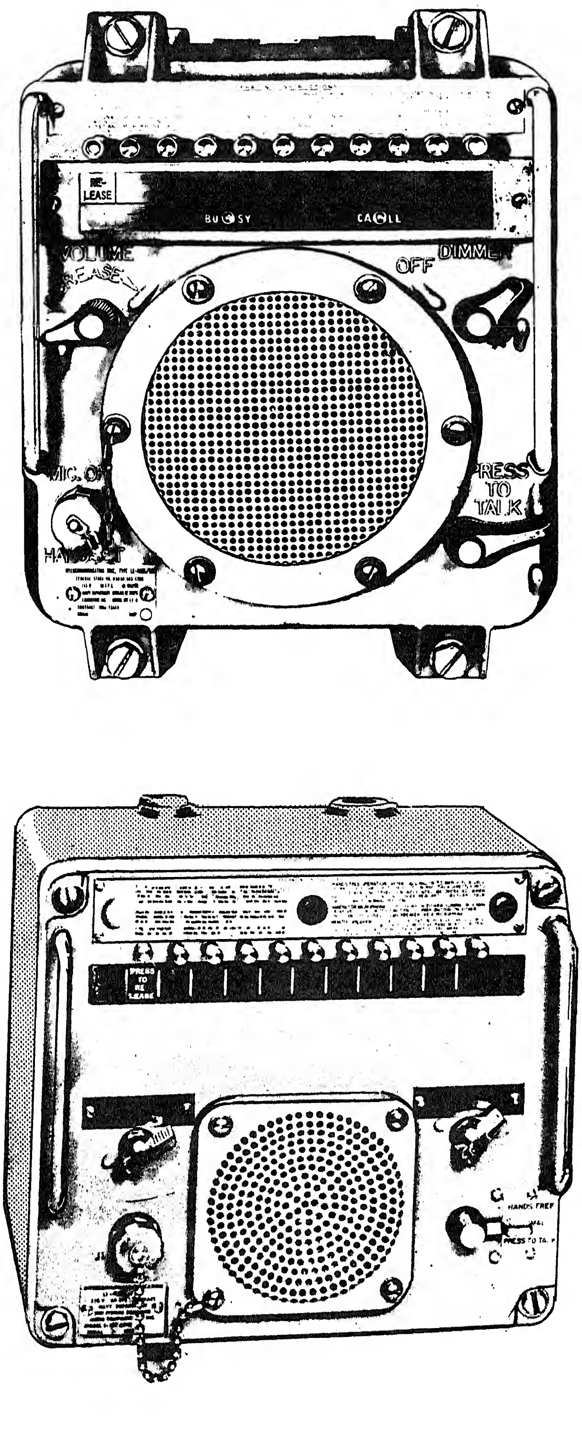
Figure 11-5 illustrates two intercom units. The units are made by different manufacturers but they are compatible, and each is capable of originating calls to as many as 10 other intercom units. There are similar units which can call 20 other stations, and there is another type which can originate calls to only two other stations.

SHIP'S ENTERTAINMENT SYSTEMS

A separate shipboard announcing system, circuit SE, is used primarily for the entertainment of ship's company and is capable of broadcasting commercial radio programs, prerecorded information, and voice announcements of an educational or entertainment nature to various locations within the ship.

SHIP'S ENTERTAINMENT EQUIPMENT

There are several different types of ship's entertainment equipment which is specifically manufactured for installation aboard naval ships. In addition, many ships have ship's entertainment systems which are composed in part or entirely of equipment designed for commercial use.



7.25:140.127
Figure 11-5.— Intercom units.

Figure 11-6 is a diagram of a typical ship's entertainment system. This system consists of various input equipment, a control/amplifier console, power amplifier assembly, and as many loudspeakers as required.

Input Equipment

The input equipment consists of those devices that supply the desired entertainment or educational programs to the ship's entertainment system. The actual composition of input equipment may vary, depending on the particular installation. A typical selection of input equipment is illustrated in figure 11-6. An additional phonograph, tape player, radio, etc. may be connected to the auxiliary input jack if desired.

Control/Amplifier Console

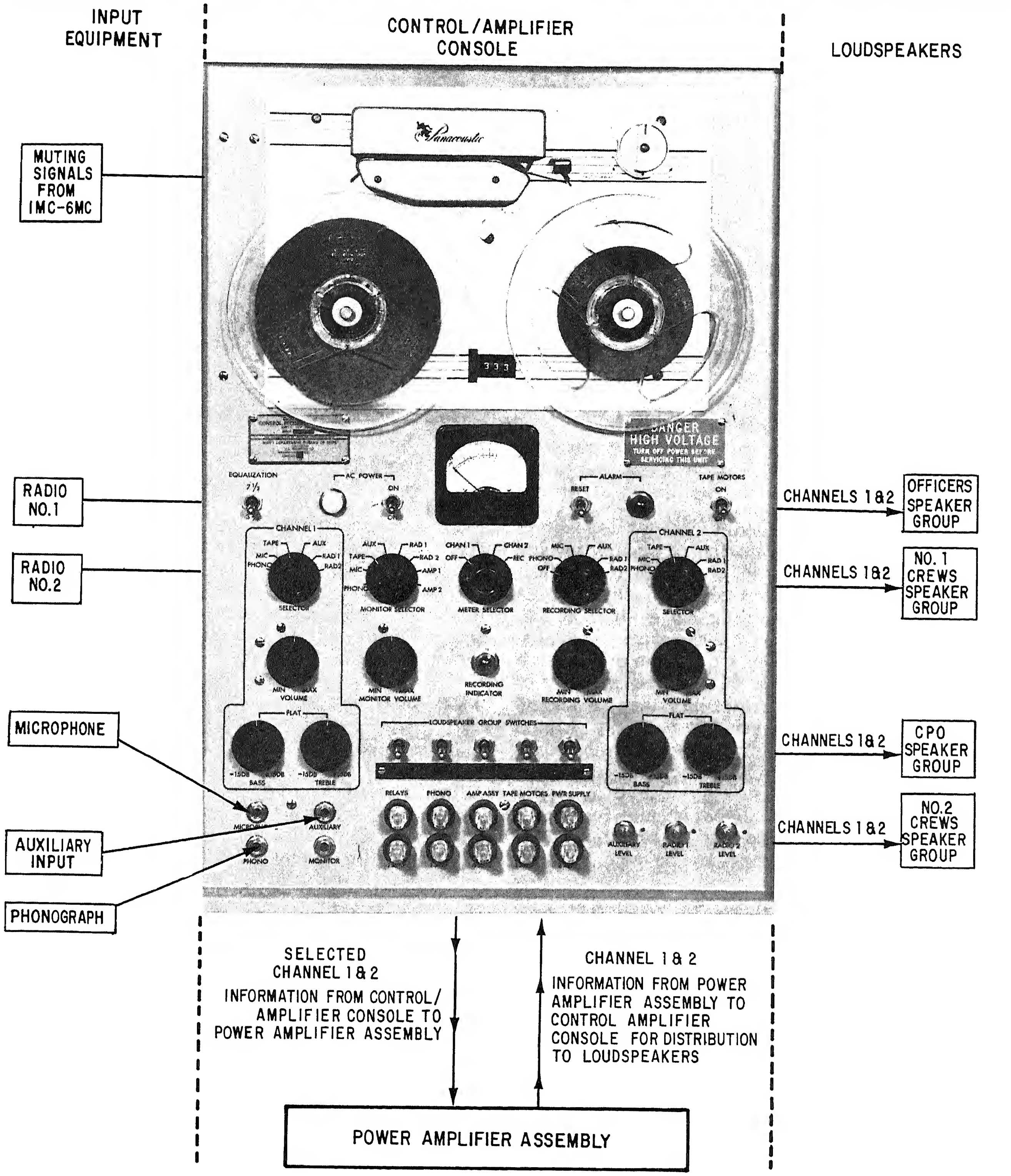
The control/amplifier console pictured in figure 11-6 is used in many shipboard installations. The console together with the power amplifier assembly contains the necessary control devices and amplifiers to accept from any two of the available inputs and to retransmit that information over two independent channels to the various loudspeakers. The console also contains a tape recorder that may be used as an input for one of the entertainment channels, or it may be used to record information for later use. As previously discussed in this chapter, control signals from the 1MC-6MC system actuate devices within the console which mute or silence ship's entertainment transmissions.

Loudspeakers

Ship's entertainment speakers are installed in berthing, messing, and recreation spaces. Each speaker unit is provided with a channel selector switch and volume control to permit the individual to select and regulate the volume of the channel he desires to hear. The loudspeakers of the ship's entertainment system are arranged in groups as they were in the 1MC-6MC system. Isolation switches (located on the control/amplifier console) permit individual speaker groups to be disconnected from the remainder of the system if desired.

Commercial Ship's
Entertainment Equipment

The entertainment systems aboard many ships are composed in part or entirely of commercial



27.340

Figure 11-6.—Basic diagram of ship's entertainment equipment.

equipment. This commercial equipment usually is more compact, less expensive, and more attractive than Navy equipment, but it presents certain disadvantages that should be considered prior to its purchase and installation. Some disadvantages are:

1. Safety—commercial equipment is not always electrically safe for shipboard use.

2. Construction—commercial equipment is not always rugged enough to withstand the rigors of shipboard use.

3. Supply support—commercial equipment is not supported by the Navy Supply System. In many instances it will be very difficult to obtain repair parts for commercial equipment.

SHIP'S ENTERTAINMENT SYSTEM OPERATION

A properly maintained and operated ship's entertainment system contributes greatly toward a happier ship's company. A poorly maintained and incorrectly operated ship's entertainment system is worse than having no system at all. It should be remembered that, at many times, the entertainment system is often the only source of world news and one of the few sources of entertainment for the ship's company. It should also be remembered that no two person's opinion of what constitutes entertainment agrees completely, and it is impossible to please everyone all the time.

The entertainment system should present a wide variety of programs. If possible, programming should be done by several persons of varied interests. Many times it will be possible to enlist the services of crew members in scheduling programs for the system.

SOUND MOTION PICTURE SYSTEMS

Sound motion picture systems are designed for training, briefing, and entertaining. The equipment used is similar to commercial motion picture projection equipment which projects 16-mm sound film for viewing. The types of equipment used and the size of installation vary with each ship. Usually ships are equipped with at least two 16-mm sound motion picture projectors and several installed or portable loudspeakers.

SOUND MOTION PICTURE FILM

The sound motion picture film is one of the most expensive components of a sound motion picture projection system; it is also the most susceptible to damage.

Film Construction

Sound motion picture film used by the Navy is identical to that used by the civilian population. It is composed of a nonflammable cellulose acetate base upon which is bonded the emulsion. The base supports and acts as the transporter or vehicle for the emulsion. The emulsion is the component in which the image, including the sound track, is recorded by the photographic process. Figure 11-7 is an exploded view of motion picture film. The edge of the film is perforated by sprocket holes, which are used to aid in transporting the film through the movie projector mechanisms. The opposite edge of the film contains the photographic record of the sound recording, the sound track. As shown in figure 11-7 the image appears inverted to the observer. The projection process causes the image to once again appear right side up on the movie screen.

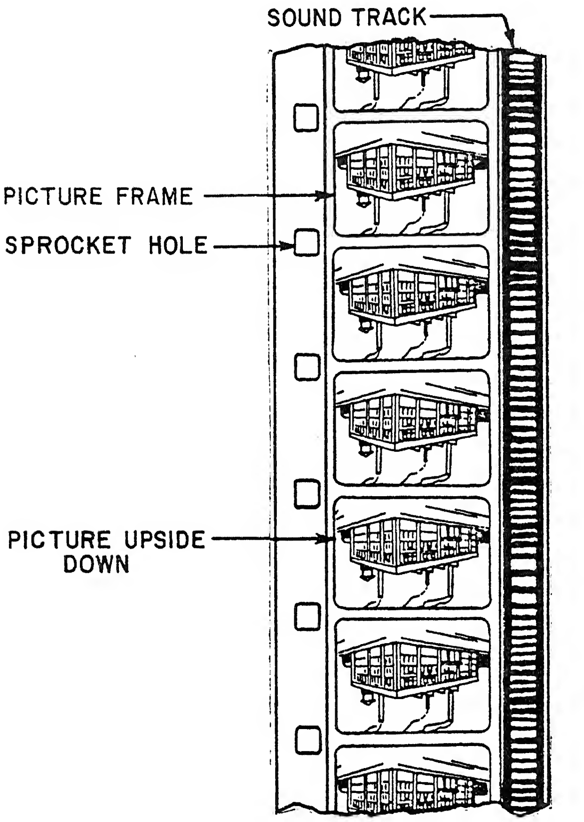
Film Care

The care of motion picture films is largely a matter of common sense. Navy motion picture films should receive the same care as one would expect to give his own films. Store them in a cool, dry place and handle them carefully.

Most film damage is a result of improper care, defective projection equipment, or improper stowage. The most common types of film damage are liquid damage, scratches, and tearing.

DAMAGE FROM LIQUIDS.—Most liquids (including water) will damage the emulsion surface of films. Exposure to liquids causes the emulsion to become discolored; figures and colors run together. The most common cause of this form of film damage are improper stowage and the careless coffee drinker.

SCRATCHES.—The emulsion of the film is a relatively soft material, and it is easily scratched. Scratched films appear to have vertical lines or bars across them and the reproduced sound portion of the film is distorted. Improper handling, defective projection equipment and poor



7.66(77C)
Figure 11-7.—Section of 16-mm film.

projector operators cause most scratched film damage. To avoid this form of damage:

1. Exercise care to keep the film and projection equipment as clean as possible.
2. Keep the projection equipment properly adjusted.
3. Ensure that projection equipment operators are properly trained.

TORN OR BROKEN FILM.—Gross mishandling by projection equipment operators or defective equipment results in broken or torn film. This type of damage can be prevented by properly maintaining your projection equipment and properly training its operators.

Film Management

Generally, motion picture film available to shipboard personnel may be categorized as being either educational or entertaining in nature. The policies for use, management, and distribution of each type is different. Entertainment films are under the cognizance of the Navy Motion Picture Service, while the policies concerning educational films are established by the Chief of Naval Education and Training. To ensure the efficient utilization of each type of film, several reports and forms must be maintained by shipboard personnel. The records required for educational films are different from those required for entertainment film.

ENTERTAINMENT FILM.—Entertainment film for shipboard viewing is available through your local Navy Motion Picture Exchange (MPX). The rules governing the operation of local MPX's and the use of their films by shipboard personnel are contained in the Navy Motion Picture Service Manual. This manual covers all aspects of entertainment film usage and handling and gives information on the use of forms, reports and records that are part of the system. The manual also specifies that all movie projector operators are to be adequately trained and designated in writing by the commanding officer. Failure to comply with the regulations contained within the manual could result in the suspension of your command's entertainment film privileges.

For purposes of familiarization, some of the records and forms associated with entertainment films are listed below. You should consult the Navy Motion Picture Service Manual for specific instructions concerning these records and forms.

Inspection and Exhibition Booklet.—Each entertainment film print has its own Inspection and Exhibition Booklet (I & E Booklet) which remains with the film as long as it is in service. The I & E Booklet serves several functions. The first pages contain a brief description of what the film is about and lists the major stars that appear in it. The remaining pages (fig. 11-8) are a record of where and when the film has been exhibited and its condition before and after each exhibition. This information aids the MPX in determining who may be responsible for any damage to the film and it also helps in determining that a film has been used sufficiently to warrant its removal from circulation. Entries on the record pages should be brief, legible, and specific. They should be made in ink, and each entry must be signed by the designated movie officer. These entries are checked by MPX personnel when the film is returned.

1 SHIP OR STATION	2 DATE OF EXHIBITION	3 CONDITION BEFORE EXHIBITION	4 CONDITION AFTER EXHIBITION	5 SIGNATURE COMMISSIONED OFFICER
U.S.S. POQUE	3-6-72	Good	Good	J.H. Coode ENS. USN
U.S.S. PROLONG	4-22-72	Good	Good	Orville Otter LTJG USN
NHPX (NORVA)	8-3-72	INSPECTED AND IN GOOD CONDITION	Good	Sam Lotte LT. NMPX OinC
U.S.S. BARNSTORM	2-1-73	Good		

27.394

Figure 11-8.—Inspection and Exhibition Booklet Record pages.

MOTION PICTURE PRINT INVENTORY CARD
NAVPERS 3045 (REV 1971)

PROGRAM NO.	PRINT NO.	MONTH	YEAR

INSTRUCTIONS: (REPORT SYMBOL BuPers 1710-6)

TO THE SHIP OR STATION HAVING CUSTODY OF THIS PRINT

1. DETACH THIS CARD ON THE LAST DAY OF THE ABOVE MONTH.
2. ENTER U-I-C CODE AND ADDRESS IN THE SPACES PROVIDED BELOW.
3. IF THIS PRINT IS RECEIVED WITH A CARD(S) FOR A PREVIOUS MONTH(S), DETACH AND SUBMIT CARD(S) IMMEDIATELY.
4. THIS IS A MONTHLY PRINT INVENTORY CARD

U. I. C.

SENDERS CORRECT MAILING ADDRESS INCLUDING ZIP CODE

AIRMAIL TO:

NAVY SPECIAL SERVICES ADMINISTRATIVE ACTIVITY
NAVY MOTION PICTURE SERVICE
311 FLUSHING AVENUE
BROOKLYN, NEW YORK 11205

PROGRAM NO. 10 13	PRINT NO. 14 15	MONTH 16 17	YEAR 18 19

DO NOT BEND OR FOLD

IBM N89569

27.395

Figure 11-9.—Motion Picture Inventory Card.

Motion Picture Print Inventory cards (fig. 11-9) are attached inside the rear cover of the I & E Booklet and provide information for the Navy Motion Picture Service to periodically account for each film and its general location. Use of the cards is self-explanatory.

Motion Picture Inspection Record.—Motion picture exchanges generally require shipboard personnel to complete a record of inspection prior to the receipt of a print. Figure 11-10 is a checkoff list which serves as a guide to the representative from your command and aids

INSTRUCTIONS
a. For preparation by movie operator prior to exhibiting of each film—to be retained on board.
b. For use by NMPX's in making routine inspections.

MOTION PICTURE INSPECTION RECORD
NAVPERS 3043 (Rev. 4-61)

PROGRAM NUMBER

PROGRAM CONDITION CODE

GENERAL PRINT CONDITION	SPECIFIC DEFECTS NOTED		
E —EXCELLENT G —GOOD U —USABLE NU—NON-USABLE	B —BRITTLE C —CRIMPS LS—LIGHT SCRATCH	HS—HEAVY SCRATCH M —MISSING N —NICKS	SPL—LIGHT SPROCKET DAMAGE SPH—HEAVY SPROCKET DAMAGE W —WATERMARKS

	NO. REELS
FEATURE CROOKS ANONYMOUS	3
SHORT SUBJECTS #1	
#2	
#3	
TOTAL REELS	3

INSPECTION FACTORS (*Use above code*)	SHORT SUBJECTS			REELS OF FEATURE					
	#1	#2	#3	1	2	3	4	5	6
PROTECTIVE LEADER				G	M	G			
SYNCHRONIZING LEADER				G	M	G			
TITLE AND CAST				LS	G	G			
PICTURE				G	W	G			
SOUND TRACK				LS	G	G			
ALONGSIDE SOUND TRACK				G	G	G			
SPROCKET HOLES				SPL	G	G			
SPLICES				G	G	G			
ENDING				G	G	M			

GENERAL PRINT CONDITION (*Use Code above*) G

REMARKS

DISPOSITION NMPX USE

VAULT NMPX USE

DATE 17 JULY 76

SIGNATURE (*Inspector*)

SIGNATURE OF MOTION PICTURE OFFICER PRIOR TO EXHIBITION

U.S. GOVERNMENT PRINTING OFFICE : 1961 OF—603881

77.269

Figure 11-10.—Motion Picture Inspection Record.

him in his inspection. Performing an inspection at the Motion Picture Exchange and noting the condition of the film will prevent your ship's being held responsible for previous damage.

Activity, Damage, Loss and Destruction Report. — Upon the discovery of loss, damage, or destruction of a print, the Motion Picture Exchange will initiate and forward an Activity, Damage, Loss and Destruction Report (fig. 11-11) to the command that last had custody of the damaged or lost print. The form is divided into two parts. The top half is filled out by the investigating MPX. The activity from which the information is requested completes the lower portion and returns the form to the requesting MPX. The MPX will attempt to affix the blame for the damaged print by the information received.

Exhibition, Transfer and Inventory Record. — The Exhibition, Transfer and Inventory Record is a monthly record of each film received by a ship. All films received by your command are recorded on this form. This form (fig. 11-12) lists the name of the print, from whom it was received, its condition after exhibition, and to whom it was transferred. The form also lists those personnel from your activity who were designated as projectionists. A new form must be prepared each month. It must be signed by the commanding officer or his designated representative (movie officer). The completed Motion Picture Exhibition, Transfer and Inventory Record forms should be retained aboard.

Notification of Motion Picture Transfer. — When ships are underway for extended periods or when they are in ports not serviced by an MPX, motion pictures may be transferred directly from one ship to another. When such exchanges are made, the Notification of Motion Picture Transfer Form (fig. 11-13) must be completed. This form, when filled out and signed by a representative of the receiving command, is a receipt for films transferred from your command.

Transfers are NOT to be made directly between ships in a port served by an MPX. Films are NOT to be informally loaned to other commands. Remember that your activity will be held responsible for any damage or loss that occurs to a film while it is officially in your custody.

Request for 16-mm Motion Picture Sea Prints. — Generally, film prints issued for use by ships while they are in port may NOT be taken to sea. Film prints that are to be taken to sea must be specifically requested on a Request for 16 mm Motion Picture Sea Prints Form (fig. 11-14). Instructions for completion and submission are listed on the form.

TRAINING FILMS. — In comparison to entertainment films the record keeping chores concerned with Navy training films are minor. Films which are of general interest to shipboard personnel are available from the Naval Education and Training Support facilities in San Diego and Norfolk. They may be obtained through official correspondence with these support facilities. Loss or damage to training films should be reported to the applicable support facility. A complete listing of available training films is contained in the United States Navy Film Catalog, NAVAIR 10-1-777.

SOUND MOTION PICTURE PROJECTION EQUIPMENT

The principles of operation of Navy projection equipment are identical to those of commercially available equipment. The 16-mm Singer Graflex Movie Projector (fig. 11-15) is a slightly modified version of commercially available equipment. This projector, however, unlike its civilian counterparts, has been tested and is considered safe for shipboard use. The fact that it is considered safe for shipboard use does not mean that it will remain so indefinitely. It means that insofar as could be determined by the testing program, when used in a reasonable manner, the projector is as safe as it is technically and economically feasible to make it.

NOTE: MOVIE PROJECTORS, LIKE ALL PORTABLE ELECTRICAL EQUIPMENT ABOARD SHIP, ARE POTENTIAL SHOCK HAZARDS AND SHOULD BE TREATED AS SUCH.

A movie projector's portability makes it susceptible to physical damage which could make it unsafe for use. Its portability means that it is not physically bonded to the ship's hull; physical damage could cause dangerous voltages to be present on its outer surfaces. These voltages await a person's contact which will cause current to flow through his body to the ship's hull.

ACTIVITY DAMAGE, LOSS AND DESTRUCTION REPORT
NAVPERS 3041A (REV. 4-61)

DATE: 6 April 197–

From: Officer-in-charge, Navy Motion Picture Exchange, NORFOLK, VA. SERIAL MPE - 100

To: Commanding Officer
U.S.S. UNDERWAY (AD-12)
c/o Fleet Post Office
New York, N.Y.

Subj: PROGRAM 2250 PRINT A2
FEATURE TITLE CROOKS ANONYMOUS (STD) B&W
SHORT SUBJECTS PENNY PALS (STD) E

1. Subject film was recently exhibited at your activity. It is requested that information be furnished concerning:

[X] Damage of film [ ] Loss of film

2. After completing the items below forward this form as indicated.

/s/ A.J. JONES, LT., USN
(Signature)

From: U.S.S. UNDERWAY (AD-12) SERIAL 185 DATE 10 April 197–
(activity name)

To: Officer-in-charge, Navy Motion Picture Service, Naval Station, 136 Flushing Ave., Brooklyn I, N.Y. 11251

1. As requested above the following report is submitted:

DATE OF EXHIBITION ON BOARD	NUMBER OF SHOWINGS ON BOARD	Is operator an MPO school graduate?
1 April 197–	TWO	[X] YES [ ] NO
Did operator thoroughly inspect film and projector before showing? [X] YES [ ] NO	Did operator note condition of film during projection and after showing? [X] YES [ ] NO	Was a Motion Picture Inspection Record prepared? [X] YES [ ] NO

REMARKS: (Furnish any details which will assist in determination of cause of damage/or loss and in establishing responsibility)

Motion Picture Inspection Record (Navpers 3043) for program 2250 - A2 indicates that subject program was in GOOD condition before and after each of the two exhibitions on board.

/s/ R.J. COX, LCDR, USN
(Signature)

3ND-P&PO 10085

77.270

Figure 11-11.—Activity Damage, Loss and Destruction Report.

U.S. NAVY MOTION PICTURE EXHIBITION, TRANSFER & INVENTORY RECORD
NAVPERS 1710/12 (4-69) (Formerly NAVPERS 3046) SN-0106-090-1200

Not to be submitted by NMPX's

MONTH	SHEET NUMBER	NAME AND NUMBER OF SHIP OR ACTIVITY
April 1971	1 OF 1	USS UNDERWAY (AD-12)

NAMES AND RATES OF QUALIFIED PROJECTIONIST'S
(If none qualified, list those temporarily authorized referencing BuPers Authority)

NAME	RATE	NAME	RATE
A.R. Jones	EM2	A.S. Young	IC3
J.D. Doe	MM3	G.W. Smith	YN2
R.B. King	EM3	A.J. Brown	EM2

INSTRUCTIONS

This form is to be prepared in duplicate.

a. The original and the copy must be presented when returning or drawing film from any Motion Picture Exchange.

b. Submit original monthly to Officer in Charge, Navy Motion Picture Service, Brooklyn.

c. Retain copy as permanent ship or activity motion picture log.

PROGRAM IDENTIFICATION		RECEIVED FROM		EXHIBITION DATA			TRANSFERRED TO	
PROGRAM NO. & DESIGNATOR 1	TITLE 2	NAME OF ACTIVITY 3	DATE RECEIVED 4	DATE SHOWN 5	NO. SHOWS 6	CONDITION OF FILM AFTER SHOWING 7	NAME OF ACTIVITY 8	DATE TRANSFERRED 9
3601-A2	SWEET NOVEMBER	NMPX BKLYN	4/1/71	4/1/71	2	GOOD	NMPX BKLYN	4/2/71
3613-A6	YOU ONLY LIVE TWICE	NMPX BKLYN	4/2/71	4/2/71	2	EXCELLENT	NMPX BKLYN	4/3/71
3618-A26	CATTLE KING	NMPX BKLYN	4/3/71	4/3/71	2	GOOD	NMPX BKLYN	4/4/71
3608-A4	YOURS, MINE AND OURS	NMPX BKLYN	4/4/71	4/4/71	2	EXCELLENT	NMPX BKLYN	4/5/71
3622-A2	SWEET NOVEMBER	NMPX BKLYN	4/5/71	4/6/71	2	GOOD	NMPX BKLYN	4/12/71
3624-A6	TO SIR WITH LOVE	NMPX BKLYN	4/5/71	4/7/71	2	GOOD	NMPX BKLYN	4/12/71
3625-A14	THE PERILS OF PAULINE	NMPX BKLYN	4/5/71	4/15/71	2	USABLE	NMPX BKLYN	4/24/71
7572-A16	THE MAN FROM NOWHERE	NMPX BKLYN	4/5/71	4/9/71	2	GOOD	NMPX BKLYN	4/12/71
7574-A22	DRACULA HAS RISEN FROM THE GRAVE	NMPX BKLYN	4/5/71	4/8/71	2	GOOD	NMPX BKLYN	4/12/71
7304-A6	ROSEMARY'S BABY	NMPX BKLYN	4/5/71	4/10/71	2	USABLE	NMPX BKLYN	4/12/71
7309-A8	FOR LOVE OF IVY	NMPX BKLYN	4/5/71	4/13/71	2	GOOD	NMPX BKLYN	4/24/71
3602-A16	HAWAII	NMPX BKLYN	4/5/71	4/16/71	2	USABLE	NMPX BKLYN	4/24/71
3610-A24	AMBUSHERS	NMPX BKLYN	4/5/71	4/5/71	2	GOOD	NMPX BKLYN	4/12/71
3648-A2	THE ODD COUPLE	NMPX BKLYN	4/5/71	4/14/71	2	GOOD	NMPX BKLYN	4/24/71
2202-A16	EXODUS	NMPX BKLYN	4/5/71	4/12/71	2	USABLE	NMPX BKLYN	4/24/71
3654-A18	DIVORCE AMERICAN STYLE	NMPX BKLYN	4/5/71	4/11/71	2	GOOD	NMPX BKLYN	4/12/71

(If more space is needed, continue on reverse)

1 April 1971
(Date submitted)

/s/ R.J. COX, LCDR, USN
(Signature)

D-33369

77.271

Figure 11-12.—U.S. Navy Motion Picture Exhibition, Transfer and Inventory Record.

NOTIFICATION OF MOTION PICTURE TRANSFER
NAVPERS 1710/1 (11-66)
(Formerly NAVPERS 3042)

DATE SHIPPED	

FROM

Navy Motion Picture Service, Naval Station, 136 Flushing Ave., Brooklyn, N. Y. 11251

TO

Officer in Charge, Navy Motion Picture Exchange, Naval Station, Pearl Harbor, Hawaii

CERTIFIED NO.	TCMD NO.	SIGNATURE
INSURED NO.	B/L NO.	

PROGRAM AND PRINT NUMBER	NUMBER OF REELS	PRODUCTION TITLE
		* TCN #N001414112P013-XX
2606-P15	3	THE WHISPERERS
2607-P15	3	OUR MAN FLINT
	1	SPOTLIGHT ON TASMINIA, TELESPORTS #728
2608-P15	3	ACT ONE
2609-P15	3	THE MAN FROM NOWHERE
		- -
		NO ENTRY BELOW THIS LINE
		1 BDLE - 71 LBS. - 1.6 CUFT.
		PLEASE RECEIPT COPY & RETURN

DATE RECEIVED	SIGNATURE
4/10/71	/s/ L. M. CASSADY, CDR, USN

INSTRUCTIONS

Forward original and a copy to the receiving activity via Air Mail. One copy shall accompany shipment and one copy shall be mailed to the Navy Motion Picture Service, U.S. Naval Station, 136 Flushing Avenue, Brooklyn, New York 11251. Originator shall enter all necessary shipping information in the spaces provided at the top of this form. Listing for each film program shall include the complete program number with print designator, number of reels in program and feature title of program. Each listing is understood to be one case unless otherwise indicated. Receiver shall acknowledge receipt by entering date of receipt and signature in the spaces provided at the bottom of this form and promptly return a copy to the originator. Receiver shall also clearly indicate any programs listed above but not received.

77.268

Figure 11-13.—Notification of Motion Picture Transfer.

REQUEST FOR 16 MM MOTION PICTURE SEA PRINTS
FLTGEN Form 1710/1 (Rev. 12/66) 0199 217 1013

14 Feb. 1976
(Date)

REF: COMSERVLANTINST 1700.4 series /or Com Serv Pac

1. All requests will be filled out in full. (Information classified CONFIDENTIAL, is to be included and the request classified CONFIDENTIAL. Information classified higher than CONFIDENTIAL is to be omitted and the statement "CLASSIFIED HIGHER THAN CONFIDENTIAL" inserted in the appropriate blanks.)

2. Request for 14 sea prints or less are to be submitted directly to the Officer-in-Charge of the NMPX where prints will be drawn.

3. Requests for 15 or more sea prints shall be submitted in original and two copies, to COMSERVLANT with a copy to the NMPX where prints are to be drawn. Requests should be submitted at least 14 days prior to the date required, whenever possible.

4. Sea prints are to be drawn from the NMPX nearest the port of departure unless a draw from another NMPX is specifically authorized by COMSERVLANT.

5. Atlantic NMPX's are located in ARGENTIA, BOSTON, BROOKLYN, CHARLESTON, GUANTANAMO, KEY WEST, LONDON, MAYPORT, NAPLES, NEW LONDON, NEWPORT, NORFOLK, PHILADELPHIA, RODMAN, SAN JUAN, and aboard deployed FBM Submarine Tenders (To be used primarly as SSBN exchanges).

From: Commanding Officer, U.S.S. BARNSTORM (D)
(Name of Ship/Activity)

To:

NO. PRINTS REQUESTED	NO. PERSONNEL	PORT OF DEPARTURE	ETD (TIME AND DATE)
23	378	NORFOLK, VA.	0900 9 MAR 1976
NO. SHIPS IN COMPANY	ISSUING NMPX		PICK-UP DATE
2	NMPX, NORFOLK, VA.		7 MAR 1976

NEXT PORT SERVICED BY NMPX	ETA (TIME AND DATE)	SIGNATURE (CO OR DESIGNATED AUTHORITY)
RODMAN, PANAMA CANAL ZONE	4 APRIL 1976	A.V. STRANGLER CAPT. U.S.N.

COPY TO:

NMPX - NORVA

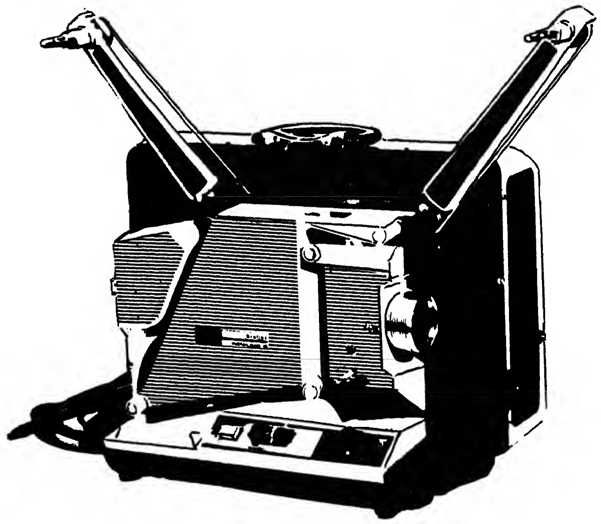
FOR NMPX USE ONLY

DATE	NO. OF SEA PRINTS ISSUED	APPROVED BY:
	(15 or more) (Excessive)	Com Serv Lant or Com Serv Pac

REMARKS:

27.396

Figure 11-14.—Request for 16-mm Motion Picture Sea Prints.



27.397
Figure 11-15.—16-mm Singer Graflex movie projector.

Projector Maintenance, Care, and Safety

Improperly maintained movie projectors have been the cause of several electrical shock fatalities and many injuries. Ensure that only approved and properly maintained motion picture equipment is used aboard your ship. Strictly adhere to 3-M Maintenance requirements and procedures.

A properly indoctrinated operator is, by far, the greatest asset in properly maintaining movie projectors and film.

The routine projector cleaning performed by the operator, prior and subsequent to each film showing, is extremely vital to the longevity of equipment and film. Dirt within the projector collects on surfaces that come in contact with the film. This dirt, if allowed to accumulate, results in scratched film. Dirt also finds its way into the projector's mechanisms and accelerates their deterioration. When badly worn projector components cannot maintain alignment with respect to each other, the resulting misalignment causes improper projector operation and torn or broken film.

Improper handling of the film and projector by the operator is another cause of damage to both film and projectors. A large amount of damage results from mishandled film and projector or incorrectly operated projection equipment.

The results of improperly trained projector operators have been listed above. However, the most important reason for training projector operators is for personal safety.

A properly trained operator is more aware of what could be a hazard to him or others and of what actions he should take when he detects a hazard.

Movie Projector Operator Training

Only those personnel who have been properly trained and designated as qualified operators of projection equipment may operate movie projectors aboard ship. Training and qualification are essential because of the potentials for electrical hazard and film damage associated with the equipment. A programmed instruction consisting of two volumes (16-mm Projector Operator, NAVEDTRA 5053-1&2, stock Nos. 0502-LP-025-2650 and 0502-LP-025-2660, Volumes 1&2 respectively) is available for training movie projector operators aboard ship. Completion of the programmed instruction and on-the-job training should provide sufficient knowledge for the trainee to meet the qualification standards as set forth in the Navy Motion Picture Service Manual and applicable on-board standards.

INTERIOR VOICE COMMUNICATIONS SYSTEM

In earlier sections of this manual a variety of the conventional voice communications systems were covered. They may be classified as belonging to one of four basic groups:

1. Sound-Powered Telephone Systems
2. Dial Telephone Systems
3. Intercommunication Systems (Intercom)
4. Central Amplifier Announcing Systems

These systems were originally designed in the 1930's and 1940's to fulfill a specific communications need. Each group has its own characteristics and each is better suited to support a particular shipboard evolution than are the other three.

The systems which are members of these groups are reliable and as a rule provide adequate

interior communications capabilities, but have two major disadvantages.

The first disadvantage is that each is designed to operate individually without provisions to interface with systems that possess different communications capabilities. Such systems require that if a user is to have access to the capabilities of all four communication groups, he must have devices that provide him access to each group (i.e., a dial telephone, a 1MC microphone control station, an intercommunications unit, a sound-powered telephone, etc.).

The second disadvantage is that individual wiring must be installed to a location for each system that the users are to have access to. Thus, as the communications needs of a location change, wiring changes must be made to add or delete the systems required.

The Interior Voice Communications System (IVCS) is an integrated communications system that attempts to solve the shortcomings of older systems. IVCS combines the features of sound-powered telephones, dial telephones, and intercommunications units into one system and it can interface with other shipboard communications systems. Additionally, IVCS provides features and services not available from any of the conventional shipboard communications systems.

IVCS

The IVCS, as installed on the new Landing Helicopter Assault (LHA) ships, is a computer-controlled circuit-switching voice communications system. The IVCS consists of terminals (user access devices), accessories, and two computer-controlled Interior Communications Switching Centers (ICSC). Two ICSC's are used to provide redundancy and are so located that simultaneous damage to both is unlikely.

Terminal Devices

Two types of terminal devices (network terminal and dial terminal) are used with the IVCS. The type of terminal, the way it is connected into the system, and the computer program determine the type of service that is provided to each user.

NETWORK TERMINAL. — The network terminal (fig. 11-16) provides service comparable to that provided by sound-powered telephone systems. By depressing one of the four numbered pushbuttons, the user will be connected to any one of four networks. The networks are hardwired circuits with a predetermined number of network terminals connected to them. The networks are connected in a manner that is similar to sound-powered telephone string circuits. Each network circuit is also connected to one of the Interior Communications Switching Centers. The nature of this connection will be covered later when the IVCS organization is discussed. The network circuits are manned for certain shipboard evolutions, as sound-powered circuits would be on a ship equipped with conventional IC systems.

DIAL TERMINAL. — The dial terminal provides service that can be most easily compared to that provided by a dial telephone system. The dial telephone terminals (fig. 11-17) are connected to the Interior Communications Switching Centers (ICSC). They are used in a manner that is comparable to a commercial dial telephone with pushbutton dialing.

TERMINAL ACCESSORIES. — There are several types of accessories designed for use with the dial and network terminals. These accessories include headsets, handsets, spraytight enclosures which permit the installation of the terminals in exposed areas, and loudspeaker units.

The loudspeaker units (fig. 11-18) are designed for use with either the dial or the network terminals. Both the units illustrated in figure 11-18 are equipped with press-to-talk switches. Additionally, by depressing the hands free pushswitch on the unit pictured in figure 11-18B, the operator can communicate without using the press-to-talk switch. Both these accessories permit terminal users to communicate without either a handset or headset, providing user service that is comparable to that provided by commercial speaker phone units.

Interior Communications Switching Center (ICSC)

The ICSC's are the heart of the IVCS. They perform the switching actions necessary to connect the calling party to the called party. In this manner the ICSC's are similar to the automatic switchboards of a dial telephone system. However, most similarity ends at this point because the design, construction, and wiring of the automatic telephone switchboard dictates the manner in which it will perform; changes to its performance can only be made by changing

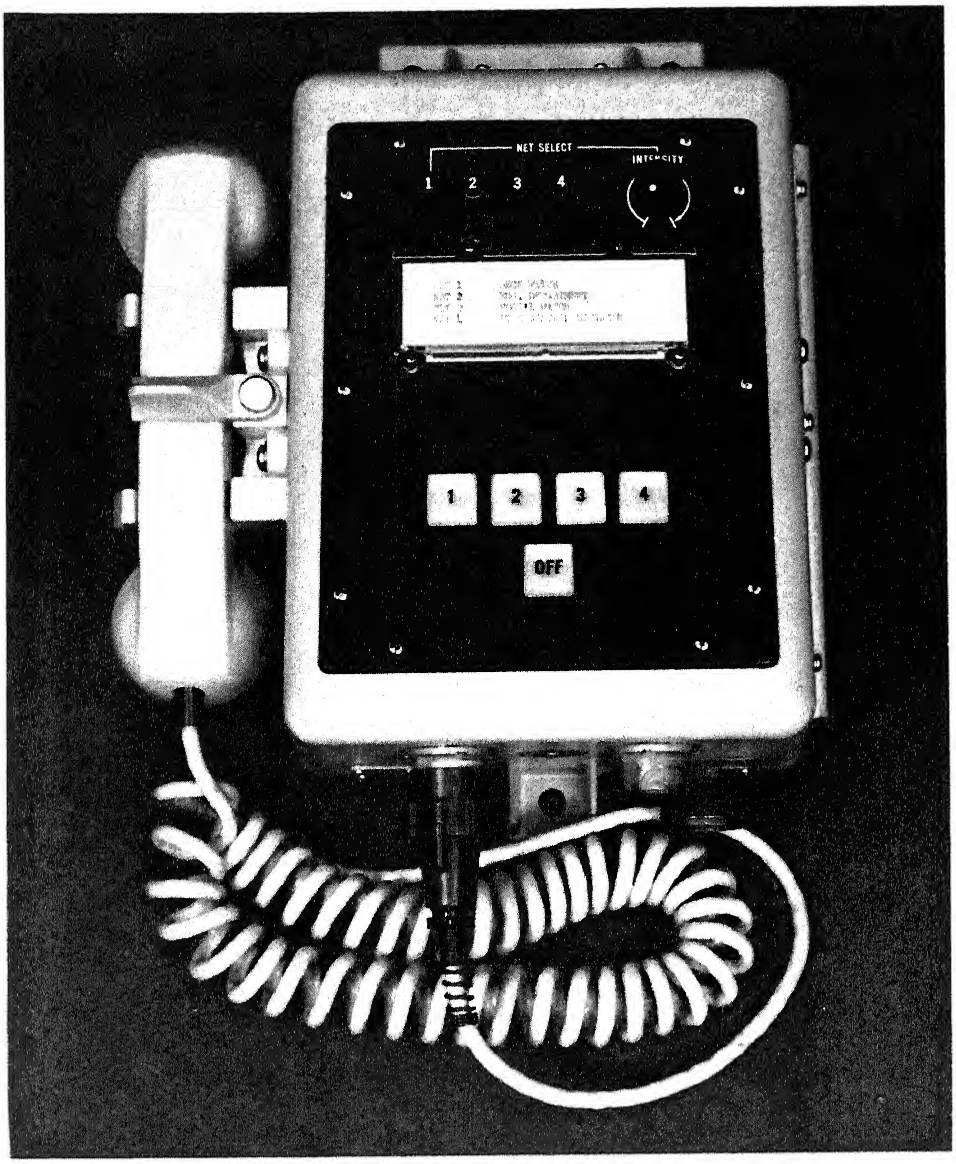


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Figure 11-16.—Network terminal.

its physical characteristics. The switching mechanisms of the ICSC's, on the other hand, are controlled by a computer and its associated memory. The switching devices of the ICSC perform their operations in a prescribed manner because the computer instructs them to do so, not because it is physically impossible for them to perform in any other way. As an example: in dial telephone systems certain telephones may cut into the conversations of others or have other special features as a result of equipment modifications. In the IVCS special features are granted to a terminal on the basis of the information stored in the computer memory. If a terminal requires the capability of cutting in on the conversations of others, instructions are placed into the computer memory which permit it to do so.

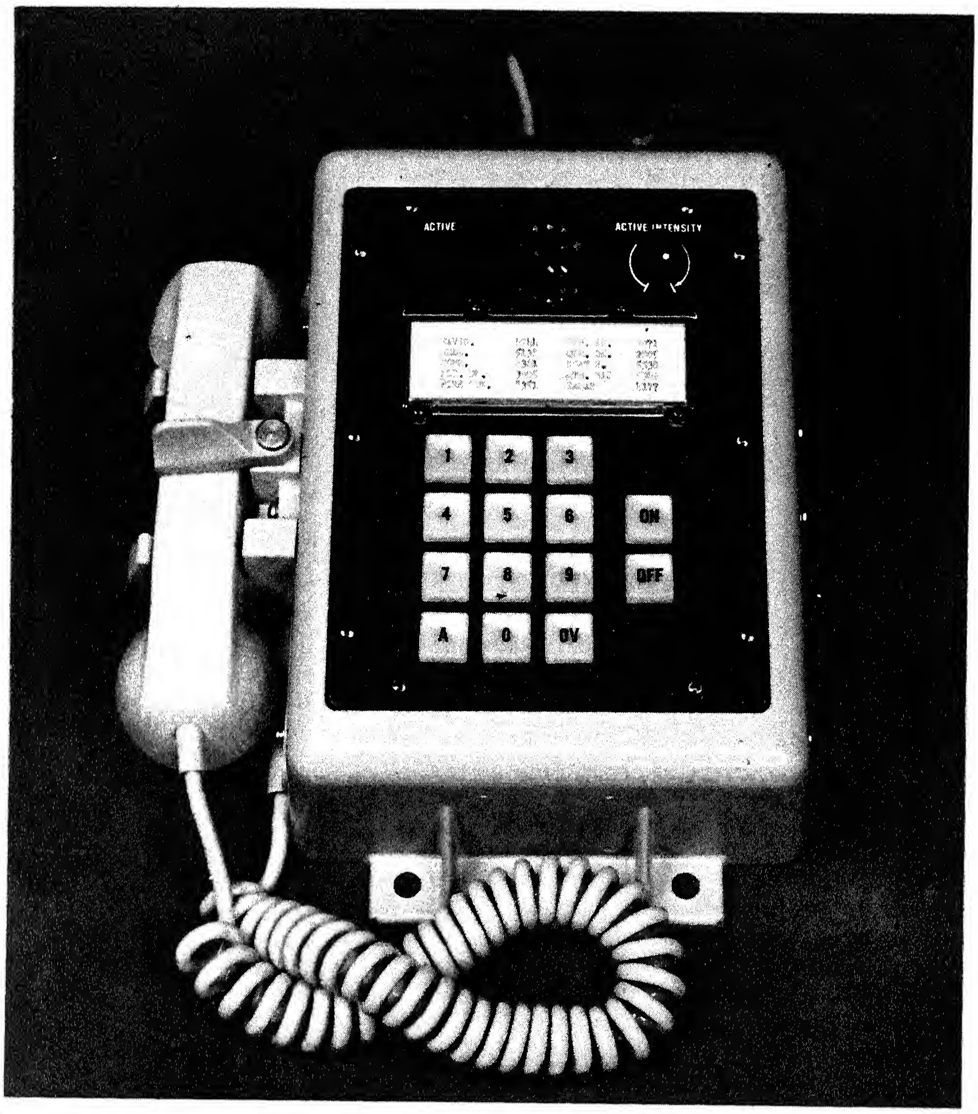

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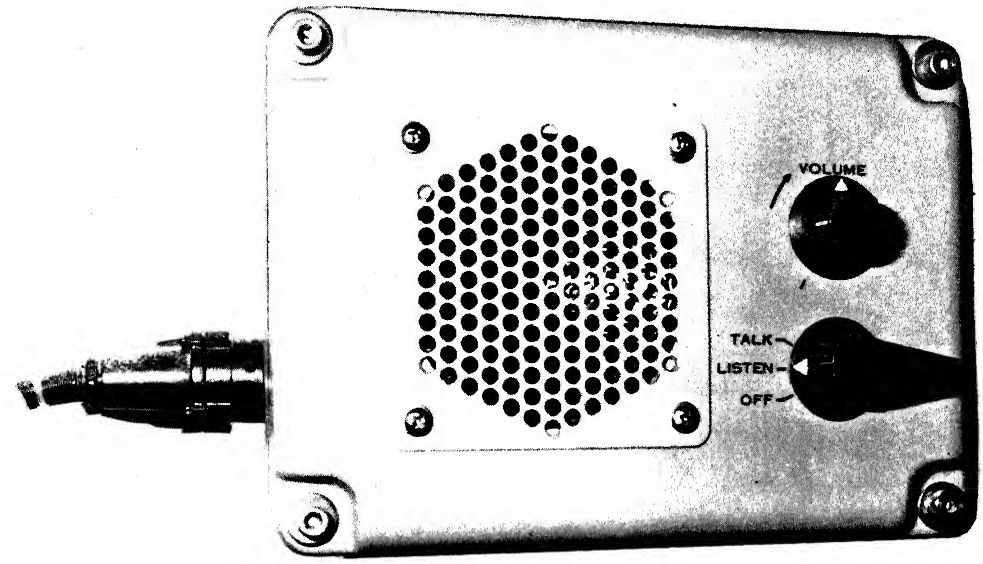
Figure 11-17.—Dial terminal.

IVCS ORGANIZATION

Figure 11-19 is a block diagram of the IVCS. As illustrated, the IVCS contains two ICSC's each of which operates independently of the other. Each ICSC receives 440 VAC power from the ship's distribution system. In addition, each ICSC is provided with standby battery supplies capable of supplying power to each ICSC for 1 hour in the event ship's power is lost. The ICSC's are connected together by the trunk and net intertie lines which permit the terminals connected to one ICSC to communicate with the terminals connected to the other ICSC. The Emergency Throwover Operation (ETO) lines also connect the two ICSC's together.

The ETO lines are part of a feature that allows an ICSC to provide service to a limited number of dial terminals normally assigned to the other ICSC. If the ICSC to which they



A. STANDARD LOUDSPEAKER UNIT

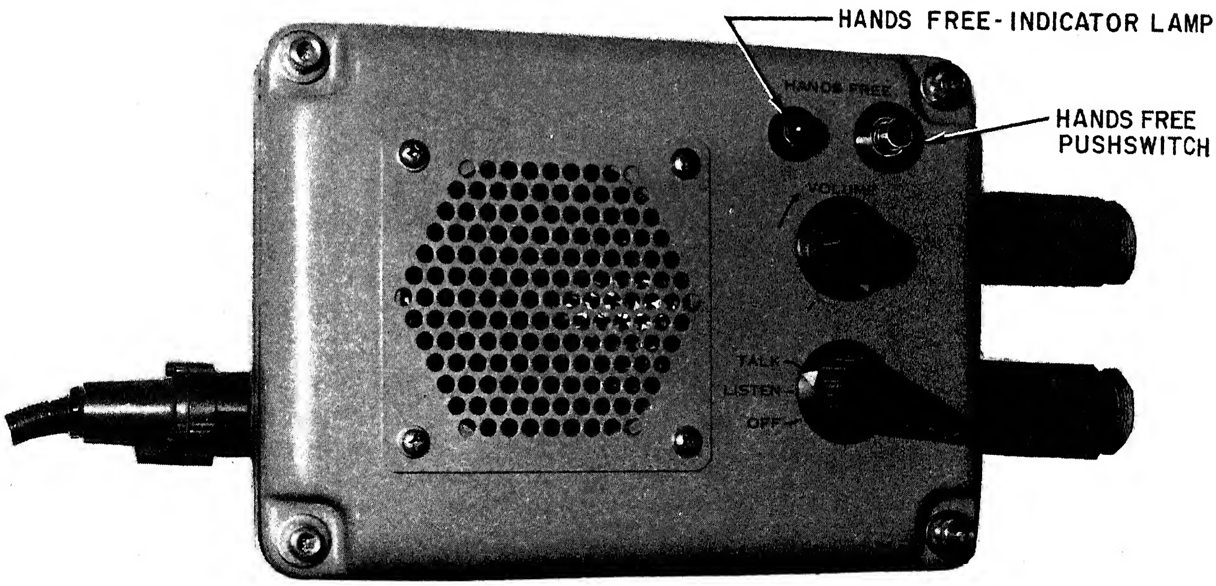


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Figure 11-18.—Loudspeaker units.

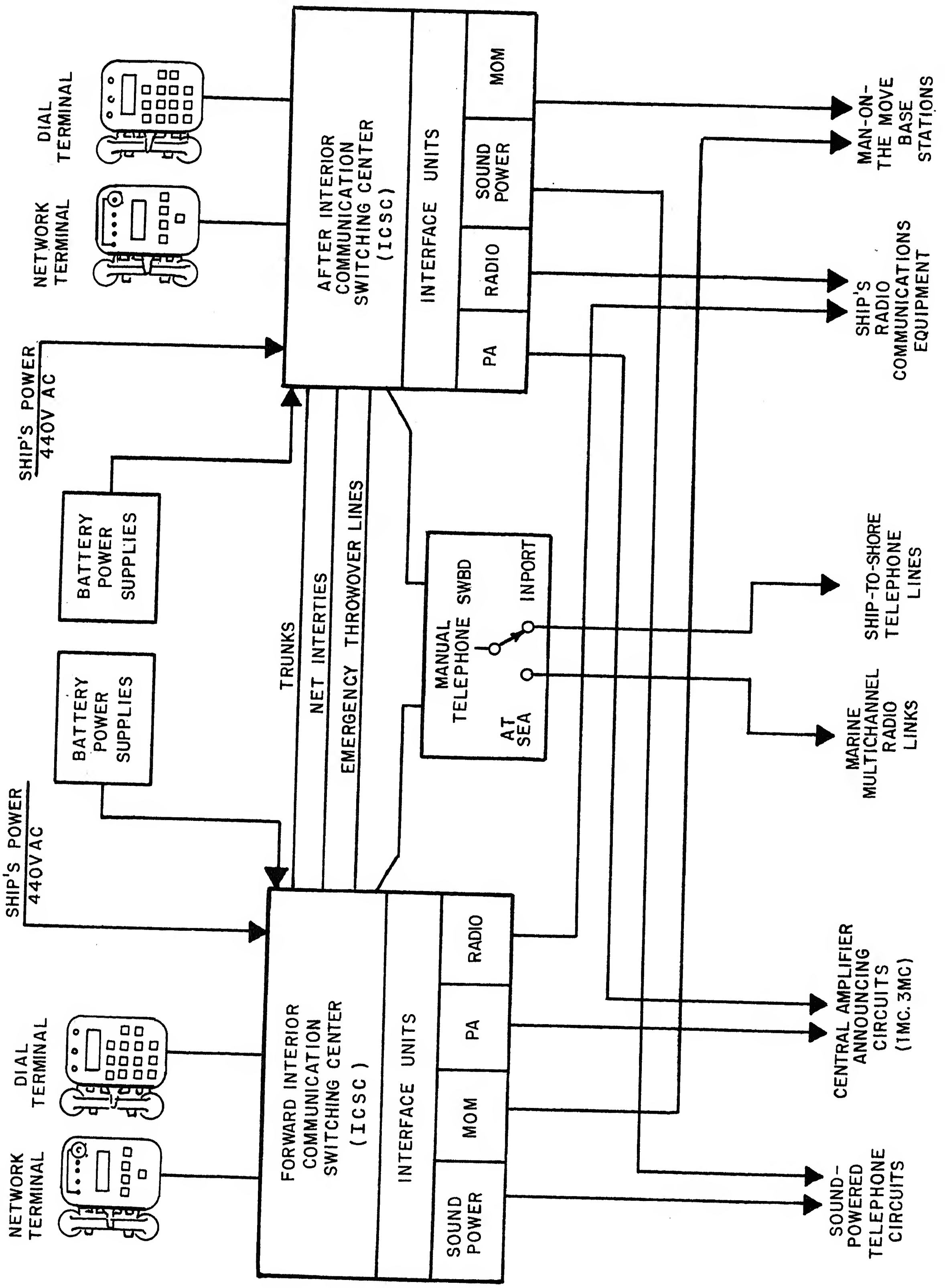

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Figure 11-19.—IVCS block diagram.

are normally assigned fails, predesignated dial terminals are served by the other ICSC through the ETO lines.

Approximately half of the dial and networks terminal devices of the IVCS are connected to each ICSC.

The dial terminals of the IVCS are connected to the ICSC's in such a way that the dial commands originated by them may be processed by the computer. The computer then causes the switching mechanisms to connect the calling party to the called party, unless it is restricted from doing so by the instructions contained within its memory.

The network terminals of the IVCS are not connected to the switching mechanisms of the ICSC's in the same manner as the dial terminals. Network terminals cannot originate calls to other terminals or networks. They are, as stated before, connected to each other to form a network circuit that is similar to sound-powered telephone string circuits. Under normal circumstances network terminals can communicate with only those other terminals connected to the same network circuit. However, the network circuits are connected to the ICSC's in such a way that it is possible for certain dial terminals (designated in the computer memory) to connect themselves through the switching mechanisms to the network circuits.

Interfaces

As shown in figure 11-9, the dial terminals connected to each ICSC can interface with the following ship's systems or equipment:

1. Ship's radio communications equipment
2. Ship's central amplifier announcing systems (1MC, 2MC, 3MC, etc.)
3. Sound-powered telephone circuits (Bridge to Bridge, weapons, etc.)
4. The manual telephone switchboard, which is part of the IVCS, is comparable to the attendant's cabinet of a dial telephone system serves two functions:
   a. Inport: It permits the IVCS to interface with up to eight shore telephone lines.
   b. At sea: It permits the IVCS to interface with eight multichannel radio links that are used primarily for amphibious operations by embarked Marines.
5. Several short-range, two-way radios that are specifically designated as the base stations for the Man-on-the-Move (MOM) Communications System. This is a special two-way radio communications system that consists of individual personal radio transceivers which provide, as the name implies, man-on-the-move communication capabilities. The MOM transceivers are operated on one of the several radio frequencies designated specifically for them. By interfacing with the base stations, the IVCS makes it possible for a dial terminal user to be connected to one of the MOM radio networks and to communicate with personnel equipped with MOM transceivers.
6. Although not actually an interface, the dial terminals may gain access to the network terminals of the IVCS through the switching mechanisms of the ICSC's.

Not every dial terminal can gain access to the above listed systems or equipment. For instance, before a dial terminal can interface with the 1MC, specific instructions must be contained within the memory of the computer which permits that individual terminal to interface with the 1MC. In this way only those dial terminals that are specifically authorized may interface with any equipment or system.

The ability to interface with other systems, as can be imagined, provides the IVCS user with communications capabilities that far exceed those of conventional interior communications systems. From one dial terminal it is possible to talk to someone in the next compartment or, through the ship's radio equipment it is possible to talk to someone on the other side of the world.

Special Features

The IVCS provides many special features, some of which are provided by conventional IC systems, but many of which are unique to the IVCS. These special features are listed below.

DUAL TONE MULTIFREQUENCY (DTMF) DIALING.—The IVCS dial terminals utilize Dual Tone Multifrequency (DTMF) Dialing, which is comparable to the pushbutton dialing used by most commercial telephone companies. Normally, the IVCS terminals utilize four digit DTMF dialing.

HUNT-THE-NOT-BUSY.—The hunt-the-not-busy feature is not new, having been used in many dial telephone systems. However, the manner in which this feature is provided by the IVCS is new. In dial telephone systems, the attendant's cabinet is usually provided with the hunt-the-not-busy feature. For the attendant's cabinet

to receive this service, wiring changes are made to a group of sequential numbers (usually 237, 238, 239, 230). Having been modified, it is possible for a party to dial the first sequential number (237) and, if that number is already in use, the switching mechanisms of the automatic switchboard steps to the next higher idle sequential number (238, 239, 230). A busy signal is received by the calling station only if all the numbers in the group are busy.

The automatic telephone system, because of equipment design, must use sequential numbers to provide the hunt-the-not-busy feature. The IVCS uses a stored program in memory and, therefore, any number can be programmed to belong to a hunt-the-not-busy group. For example, 7142, 5237, and 7413 can be in a hunt-the-not-busy group. These numbers can easily be changed, simply by changing that portion of the memory that pertains to them.

CONFERENCE CALL.—The conference call feature permits a dial terminal, which is authorized in the system memory, to dial up to five other terminal numbers at the same time and set up a conference call. All six parties can then converse with one another.

COMMAND NET.—The command net feature permits a dial terminal, which is authorized in the system memory, to dial a special four-digit code. Dialing of this special code causes up to 30 predesignated (in memory) terminals to be rung at the same time. As the called terminals are answered, they join the command net and all parties can converse with each other.

PRIVACY OVERRIDE.—The privacy override feature permits a dial terminal, which is authorized in the system memory, to complete a call whether or not the called terminal is busy.

If a called terminal is busy, the override (OV) pushbutton is depressed on the dial terminal (fig. 11-17), and the number is redialed to permit the calling terminal to join the busy parties. A 1-second tone is generated and placed on the busy circuit to alert the persons on the busy circuit that someone has joined their conversation.

RING OVERRIDE.—All dial terminals that do not have the privacy override feature will automatically have the ring override feature.

If the called terminal is busy, the override (OV) pushbutton is depressed and the number is redialed. Three short tones are placed on the audio lines of the busy parties. These tones alert the busy terminals that someone is trying to call one of them. The busy terminals should then complete their conversation as quickly as possible and hang up to allow the other party to call.

CALL FORWARDING.—Call forwarding permits the user of a dial terminal, which is authorized in the system memory, to have his incoming calls forwarded to another terminal. For instance, the captain might be expecting an important call, but an appointment requires his presence in the wardroom. By dialing a special code the captain can instruct the computer to direct all his incoming calls to the wardroom. After these instructions are placed into the system, anyone dialing the captain's terminal will cause the wardroom terminal to ring. Upon returning to his cabin, the captain dials another code and cancels his call-forwarding instructions.

ABBREVIATED ADDRESSING.—Abbreviated addressing permits authorized dial terminals to call certain other terminals by depressing the (A) pushbutton (fig. 11-17) and one numerical pushbutton. The dial terminal that is to use abbreviated addressing designates up to 10 frequently called terminals in the system memory. By depressing the abbreviated address pushbuttons, the calling terminal is connected to the called terminal. This feature, in conjunction with a loudspeaker accessory, provides user service that is similar to that provided by conventional intercom units.

IVCS SUMMARY

As you can see from the previous discussion, the IVCS offers many features and services not provided by the conventional interior communications systems. The system described herein is presently planned for installation in LHA's only. Although these ships represent only a small part of the overall ships' population, more of these systems, or similar systems, will be installed in future ship types.

CHAPTER 12

GYROCOMPASSES

Gyrocompasses are devices which use the principle of a gyroscope to obtain an indication of true north. Gyrocompass systems develop own ship's heading and transmit information to various navigation and weapons stations and to other equipment throughout the ship. Gyrocompasses are identified by the mark-mod system. The mark (Mk) number designates a major development of a compass. The modification (Mod) number indicates a change to the major development.

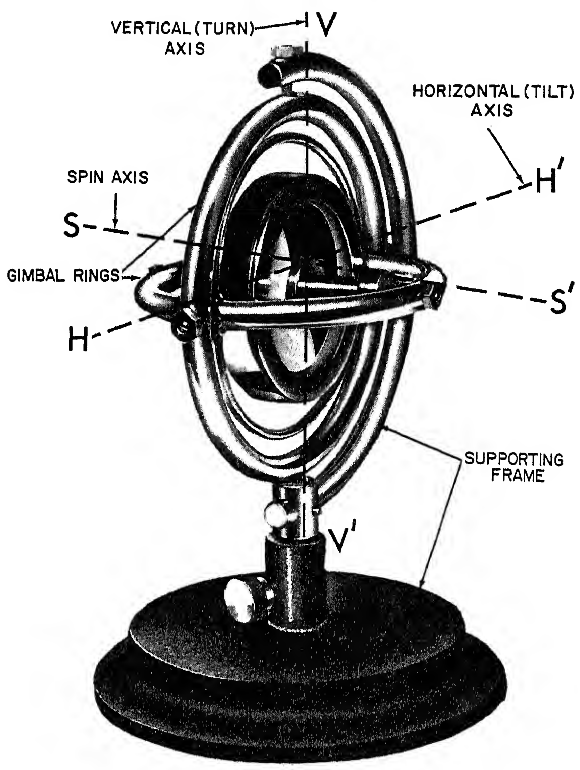
Gyrocompasses depend on the physical properties of the spinning gyroscope and the effects of the earth's gravity and rotation for their operation. In this chapter we shall discuss:

(1) The basic gyroscopic principles as they apply to a functional gyrocompass system.

(2) The basic operating principles of the Mk 23 and Mk 19 gyrocompasses.

(3) Gyrocompass records and logs.

You will find additional information in current editions of Synchro, Servo and Gyro Fundamentals, NAVEDTRA 10105; IC Electrician 3&2, NAVEDTRA 10558; IC Electrician 1&C, NAVEDTRA 10557; and the manufacturer's manual for your specific installation.



77.194

Figure 12-1.— The gyroscope.

THE GYROSCOPE

The gyroscope is a heavy wheel, or rotor, suspended so that its axle is free to turn in any direction. The rotor axle is supported in a ring by two bearings at S and S', as illustrated in figure 12-1. This ring is supported inside a slightly larger outer ring by studs and bearings at H and H'. The outer ring is mounted in the supporting frame by studs and bearings at V and V'. The inner and outer rings are called gimbals. The supporting frame is not a part of the gyroscope but merely supports it. The rotor and the two gimbals are balanced about their axes. The axes are mutually perpendicular and intersect at the rotor's center of gravity. The bearings of the rotor at points S and S' and the gimbals at points V, V', H, and H' are considered to be completely free of friction. Actually, there is always some friction, but it has been reduced to such an extent that it is considered nonexistent.

THREE DEGREES OF FREEDOM

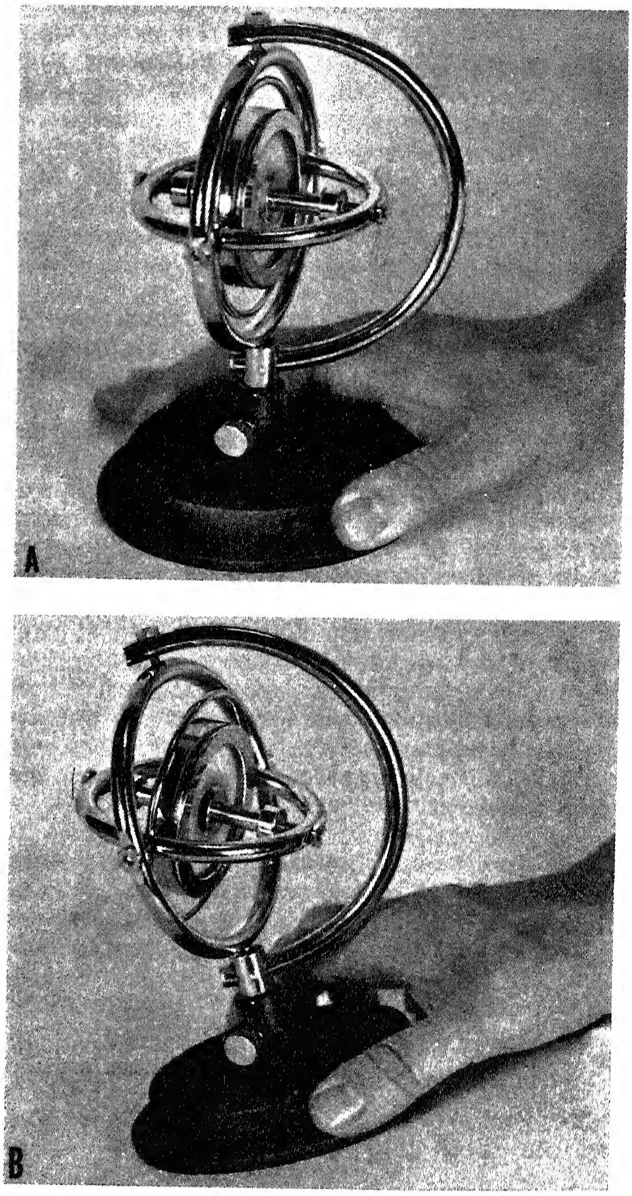
The gyroscope rotor has three degrees of freedom—freedom to spin, freedom to turn, and freedom to tilt—which permit the rotor to assume any position within the supporting frame (fig. 12-1). The rotor is free to spin about its own axle (spinning axis S-S')—the first degree of freedom. The inner gimbal ring is free to tilt on its bearings about the horizontal axis (H-H')—the second degree of freedom. The outer gimbal ring is free to turn on its bearings about the vertical axis (V-V')—the third degree of freedom.

GYROSCOPIC PROPERTIES

When a gyroscope rotor is spinning rapidly, the gyroscope develops two properties—rigidity of plane and precession—which it does not have when the rotor is at rest. Rigidity of plane and precession together with the earth's gravity and rotation make it possible to convert a gyroscope into a gyrocompass.

Rigidity of Plane

When the rotor of a gyroscope is set spinning with its axle pointed in one direction (fig. 12-2A), the rotor continues to spin with its spin axle pointing in the same direction, no matter how the supporting frame of the gyroscope is tilted or turned (fig. 12-2B). As long as the gimbal bearings are frictionless and the rotor spins, no amount of turning of the supporting frame can change the plane of the rotor with respect to space. This property of the gyroscope is known as rigidity of plane, gyroscopic inertia, rigidity in space, or stability. It can be explained by Newton's first law of motion which states that a body in motion will continue to move at a constant speed in a straight line unless acted upon by an outside force. The rigidity of the gyroscope may be increased by (1) making the rotor heavier, (2) by causing the rotor to spin faster, or (3) by concentrating most of the rotor weight near its circumference. If two rotors with cross sections like those shown in figure 12-3 are of equal weight and rotate at the same speed, the rotor in figure 12-3A



27.128(77A)
Figure 12-2.—Rigidity of plane of spinning gyroscope.

will be less rigid than the rotor in figure 12-3B. This condition exists because the weight of the rotor in figure 12-3B is concentrated near the circumference. Gyroscopes and gyrocompass rotors are both constructed with most of their weight concentrated near the circumference.

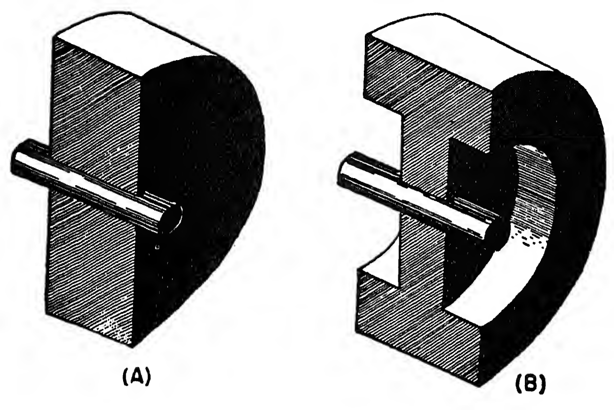


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Figure 12-3. — Weight distribution in rotors.

Precession

As previously stated, because of rigidity of plane, movements of the supporting frame have no effect on the direction in which the spin axle of a spinning gyroscope points. To change the direction in which the axle points, you must apply a force to the gyroscope rotor about its spin axis. A downward force on one end of the rotor axle attempts to tilt the gyroscope about the horizontal axis and, if the rotor is not spinning, the axle will tilt in response to the force. However, if the rotor is spinning, as in figure 12-4A, its rigidity will resist any attempt to tilt the rotor about the horizontal axis and, instead, the gyroscope will precess about the vertical axis. Any force (F) attempting to turn the spinning gyroscope about the vertical axis is similarly resisted and results in precession (P) about the horizontal axis (fig. 12-4B).

Any force that tends to change the plane of rotation causes a gyroscope to precess. Precession continues as long as there is a component of force acting to change the plane of rotation, and precession ceases immediately when the force is removed.

If the plane in which the force acts moves at the same rate and in the same direction as the precession which it causes, the precession will be continuous. This is illustrated by figure 12-5 in which a weight W representing an unbalanced condition about the horizontal axis is

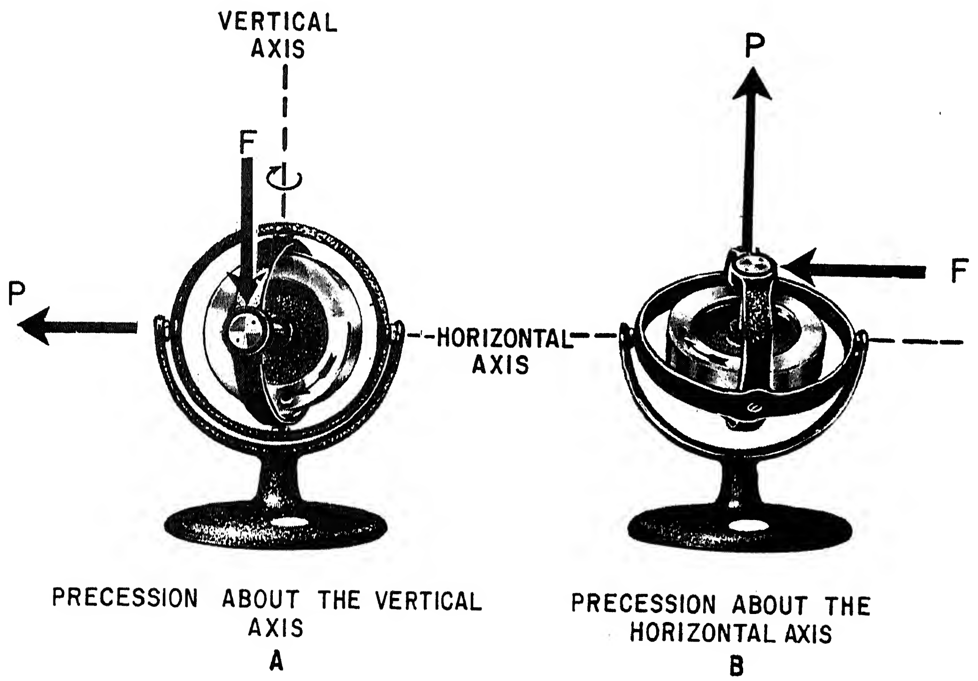

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Figure 12-4. — Precession.

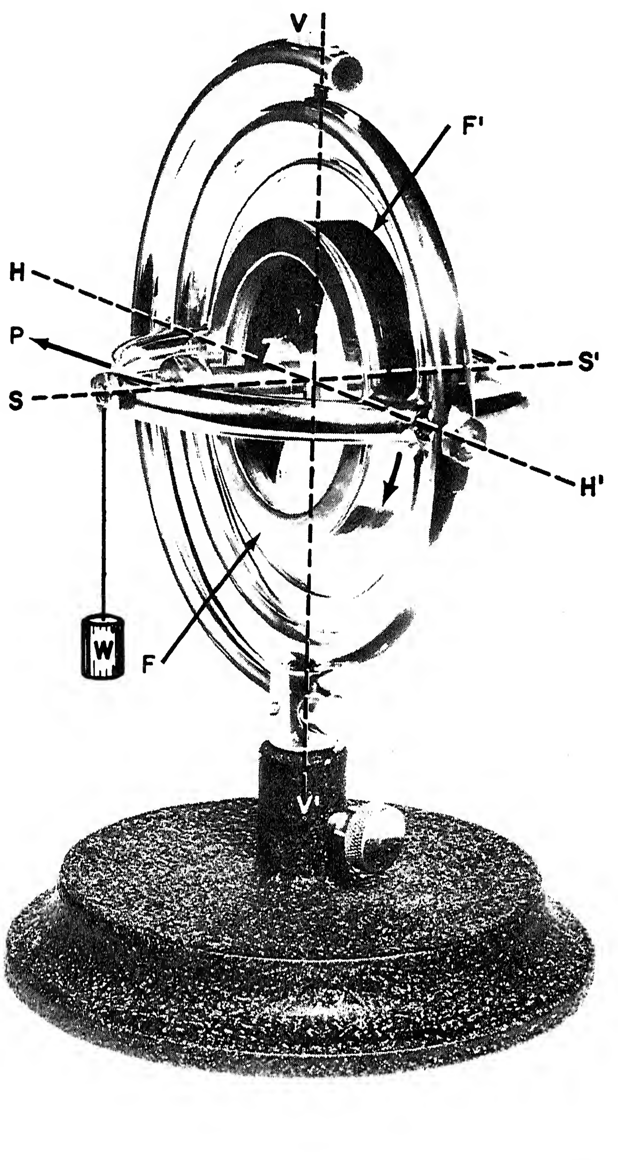

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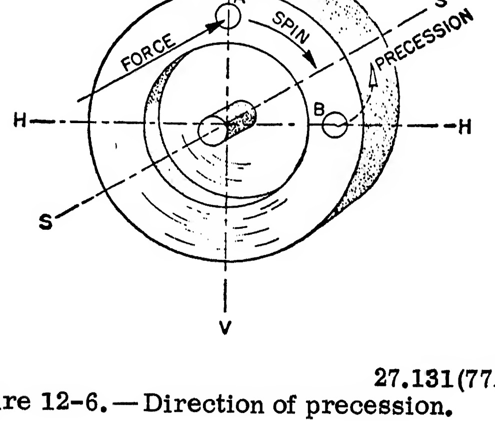
Figure 12-5.— Continuous precession.

suspended from the end of the spin axle. Although the weight is exerting a downward force, it must be remembered that the force it produces against the particles in the spinning wheel is horizontal. This force is imparted to the particles in the wheel as exemplified by arrows F and F'. If the wheel rotates clockwise as seen from the weighted end, precession will occur in the direction of arrow P. As the gyroscope precesses, it carries the weight around with it so that forces F and F' continuously act at right angles to the plane of rotation, and precession continues indefinitely.

A simple way to determine the direction of precession is illustrated in figure 12-6. Consider the force that tends to change the plane of rotation of the rotor as it is applied to point A at the top of the wheel. This point does not move in the direction of the applied force, but a point displaced 90° in the direction of rotation moves in the direction of the applied force. This is the direction of precession.

Forces of Translation

Whereas, forces which attempt to turn and tilt a gyroscope cause precession, forces which act in a straight line through the center of gravity of a gyroscope will not cause precession and are known as forces of translation. Forces which produce precession may be classified as twisting forces or torques which act about either the vertical or horizontal, or both the vertical and horizontal axes. Forces of translation do not impart a twisting force or torque about any axes, but, to repeat, they act in a straight line through the center of gravity of the gyroscope. Referring back to figure 12-1, you can see that the gyroscope is suspended by gimbal rings in such a way that the spin, vertical, and horizontal axes bisect at a point that also coincides with the gyroscope's center of gravity. Any force acting in a straight line along one of these axes or any force acting simultaneously along two or all three of the axes is a force of translation and



27.131(77A)
Figure 12-6.—Direction of precession.

will not cause precession. Thus the base and gimbaling system of the gyroscope provide it with not only the three freedoms but also permit the gyro to be moved as a unit in any direction without causing precession.

EFFECT OF EARTH'S ROTATION

As explained previously, a spinning gyroscope can be moved in any direction without altering the angle of its plane of rotation. If the base of a free-spinning gyroscope were placed on the earth's surface at the equator with the spinning axis of the gyroscope horizontal and aligned east and west, an observer in space above the north pole (fig. 12-7) would note that the earth rotates counterclockwise from west to east and carries the gyroscope along. As the earth rotates, rigidity of plane keeps the gyroscope's spin axle pointed in the same direction at all times. Assume that the gyroscope is set spinning at 0000 hours with its spinning axis aligned east and west and parallel to the earth's surface. At 0600, 6 hours after the gyroscope was started, the earth has rotated 90° but the axle of the gyroscope is still aligned as before. At 1200 the earth has rotated 180° while the gyroscope retains its original alignment. At 1800 the earth has rotated 270° while the gyroscope still retains its original alignment. At 0000 the earth has rotated 360°, the gyroscope has returned to its original starting position, and throughout the 24-hour period the alignment of the spin axle of the rotor has remained constant.

The effects of rigidity of plane described above appear quite differently to an observer standing on the earth's surface. As the earth rotates, the observer moves with it, and the gyroscope wheel appears to rotate about its horizontal axis. Figure 12-8 shows how this spinning gyroscope is placed on the earth's surface at the equator at 0000 hours with the darkened end of the spinning axis horizontal and pointing toward the observer. At 0600, 6 hours after the gyroscope was started, the earth has rotated 90° and the gyroscope axle apparently has tilted. To the observer, the darkened end of the axle points straight up and is vertical to the earth's surface. At 1200 the darkened end of the gyroscope axle is horizontal again, but it now points away from the observer. At 1800 the darkened end of the gyroscope axle is again vertical and points straight down. At 0000 the earth has rotated 360° and the gyroscope appears to the observer to be back in its original position while, in fact, it has been fixed in space for the entire period.

The rotation of the gyroscope axle as seen by the observer on the earth's surface is known

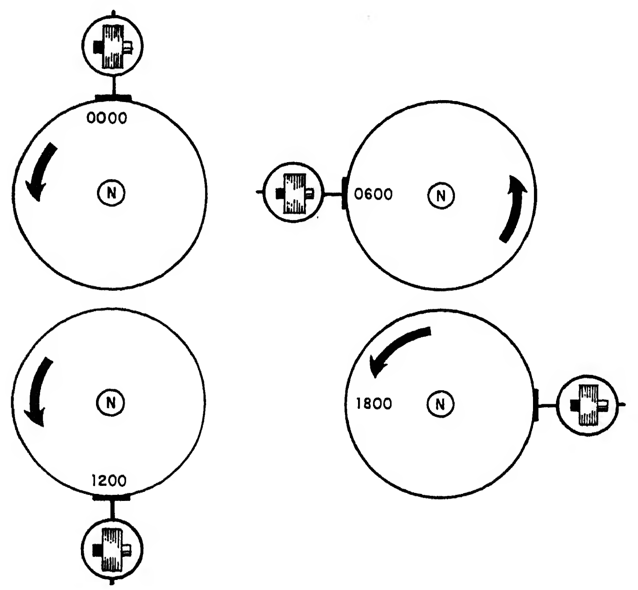


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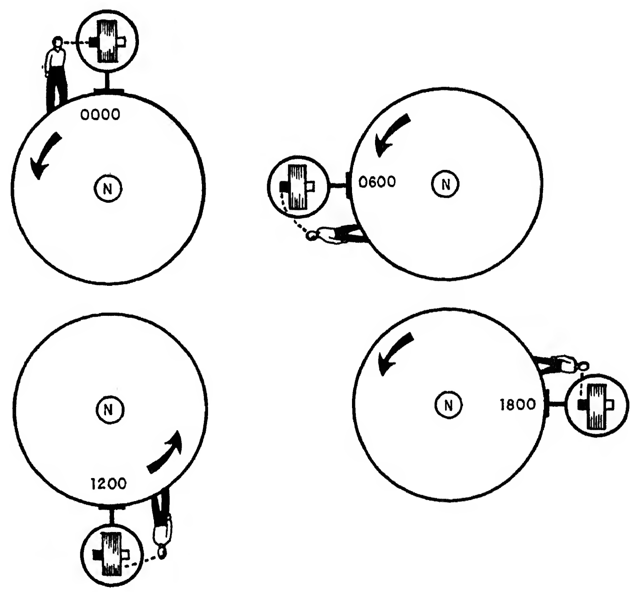
Figure 12-7.—Free gyroscope at the equator viewed from space above the north pole.



12.144(77A)B
Figure 12-8.—Spinning gyroscope at the equator viewed from the earth's surface.

as apparent rotation. Apparent rotation is caused by rigidity of plane which maintains the plane of the gyroscope wheel parallel to its original position in space. The apparent rotation that makes a gyro appear to tilt about the horizontal axis is referred to as horizontal earth rate (H.E.R.) effect. This effect varies with the cosine of the latitude and is maximum at the equator and zero at the poles.

Now assume that the spinning gyroscope, with its spinning axis horizontal, is moved to the north pole (fig. 12-9). To an observer in space above the north pole, the gyroscope axle remains fixed and the earth rotates under it. To an observer on the earth's surface, the gyroscope appears to rotate about its vertical axis. This apparent rotation about the vertical axis is referred to as vertical earth rate (V.E.R.) effect, and it varies with the sine of the latitude. It is maximum at the poles and zero at the equator.

When the spin axis of the gyroscope is aligned so that it is parallel to the earth's spin axis, apparent rotation will take place around the gyroscope's spin axis and it cannot be readily observed.

When placed at any point between the equator and either pole, a gyroscope whose spinning axis is not parallel to the earth's spinning axis has an apparent rotation that is a combination of horizontal earth rate and vertical earth rate. The combined earth rate effects at this point make the gyroscope appear to rotate partly about the horizontal axis and partly about the vertical axis. The H.E.R. causes the gyro to appear to tilt about its horizontal axis and the V.E.R. causes the gyroscope to appear to turn about its vertical axis. The magnitude of the apparent turn or tilt is dependent on the latitude where the gyroscope is located. At latitudes near the equator, the gyro appears to tilt more than turn. At latitudes near either pole the gyro appears to turn more than tilt. This apparent rotation is illustrated in figure 12-10 by a spinning gyroscope with its spin axis pointed north and parallel to the earth's surface at 45° N latitude. To an observer on the earth's surface, the gyroscope appears to both turn and tilt.

To summarize, a gyroscope, if set on any part of the earth's surface with its spinning axis not parallel to the earth's spin axis will appear to rotate. The H.E.R., which is maximum at the equator and zero at the poles, causes the gyroscope to appear to tilt about its

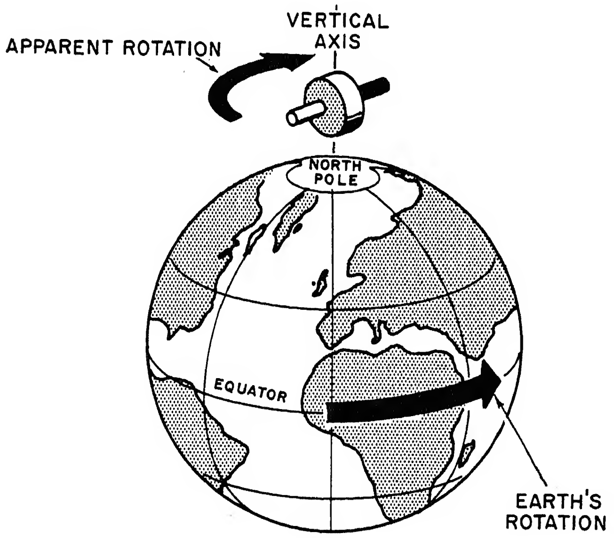


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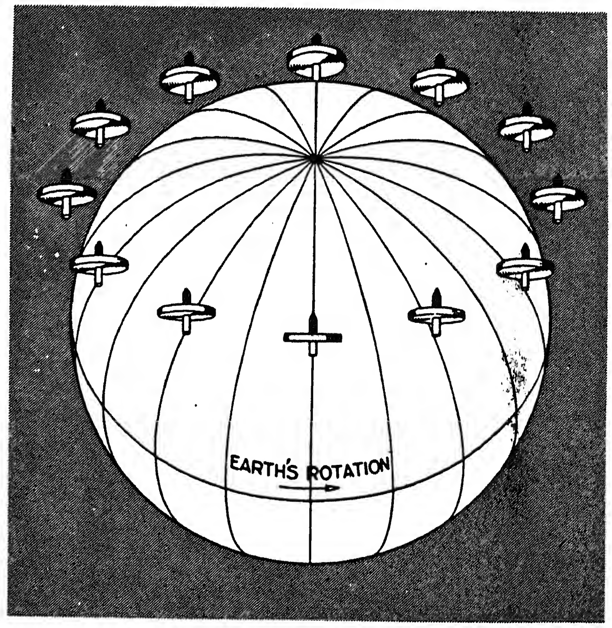
Figure 12-9.—A gyroscope with its spin axis set horizontal at the north pole; observed from a point in space beyond the equator.



77.199(140B)

Figure 12-10.—Apparent rotation of a gyroscope at 45°N latitude.

horizontal axis. The V.E.R., which is zero at the equator and maximum at the poles, causes the gyroscope to appear to turn about its vertical axis. At any latitude between 0° (equator) and 90°N or 90°S (north or south poles), the apparent rotation of the gyroscope will take place about the horizontal and vertical axes simultaneously.

MAKING THE GYROSCOPE INTO A GYROCOMPASS

We have discussed the properties of the simple gyroscope and the effects of the earth's rotation upon it. Now, let us investigate the manner in which rigidity of plane and precession plus the effects of horizontal earth rate and gravity may be used to make a simple gyroscope align its spin axis north-south and maintain that alignment.

Before the simple gyroscope is converted into a gyrocompass, its base and gimbaling rings (as shown in fig. 12-1) will be changed as shown in figure 12-11A. The simple gyroscope is modified by replacing the inner gimbal with a sphere or case, a feature of all gyrocompasses which serves to protect the rotor. Also, the base has been replaced by a phantom ring, or phantom. The phantom differs from the base of a simple gyroscope in that the base of the simple gyroscope is stationary, whereas, the phantom of the modified gyroscope is driven by a servomechanism (not shown) so that it is maintained in alignment with the spin axis of the gyroscope. The servomechanism that drives the phantom also positions the compass card and the synchro transmitters which provide indications of own ship's heading (OSH). Look again at figure 12-11A. The gyrosphere of the modified gyroscope provides the rotor with the freedom to spin. The vertical ring provides the gyrosphere with the freedom to turn; the vertical ring is suspended from the phantom so that it is free to tilt, and the phantom is maintained in alignment with the spin axis of the gyroscope by a servomechanism. Further, to become a gyrocompass the gyro must be modified so that it can:

1. Align its axis on the north-south plane (meridian)
2. Align its axis nearly horizontal
3. Maintain its alignment horizontally and on the meridian, once attained.

SEEKING THE MERIDIAN

The first step in making the modified gyroscope into a gyrocompass is to make the gyro seek the meridian. To do this, a weight W is added to the bottom of the vertical ring as shown in figure 12-11B. This weight causes the previously balanced gyro rotor/vertical ring assembly to become unbalanced about its horizontal axis, being heavier at the bottom than at the top. The modified gyroscope and weight are placed at the equator with the gyroscope

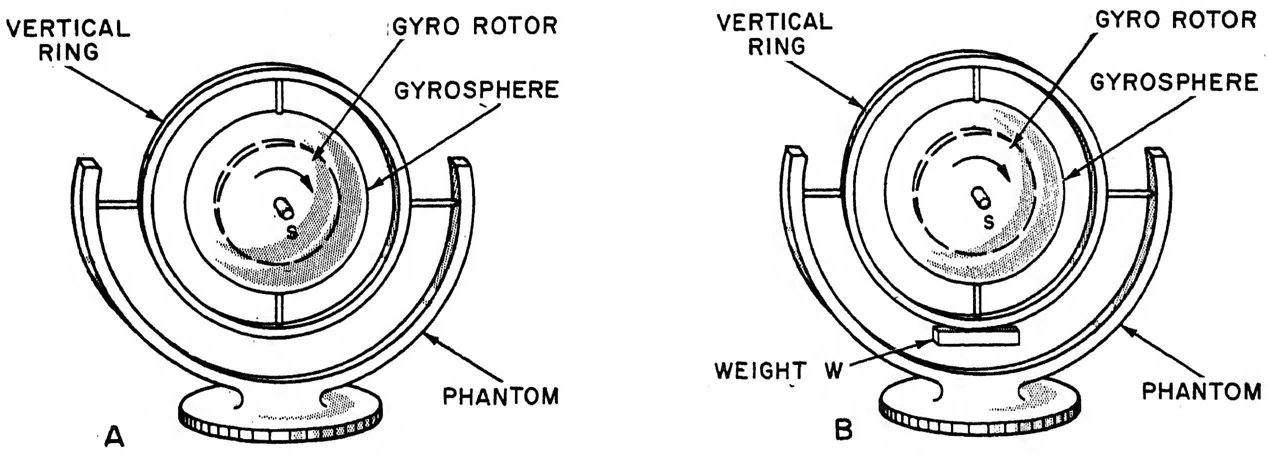


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Figure 12-11.—A. Modified gyroscope. B. Modified gyroscope with weight.

spin axis horizontal, pointing east-west, and the rotor spinning clockwise as viewed from the west (point A, fig. 12-12A and 12-12B). As the earth rotates, the east end of the gyroscope spin axis rises in relation to the earth's surface (point B, fig. 12-12A and 12-12B). This action is the result of rigidity of plane, which causes the gyroscope to point in the same direction, and H.E.R., which causes the gyro to appear to tilt about its horizontal axis in relation to the earth's surface. As the gyro and vertical ring appear to tilt, the weight W rises against the pull of gravity. The earth's gravity acts against the weight and causes a torque to be applied about the horizontal axis of the gyroscope. This torque causes the gyroscope to precess about its vertical axis in the direction indicated at point C in figures 12-12A and 12-12B; the gyroscope spin axis then has moved and the spin axis is no longer aligned east-west.

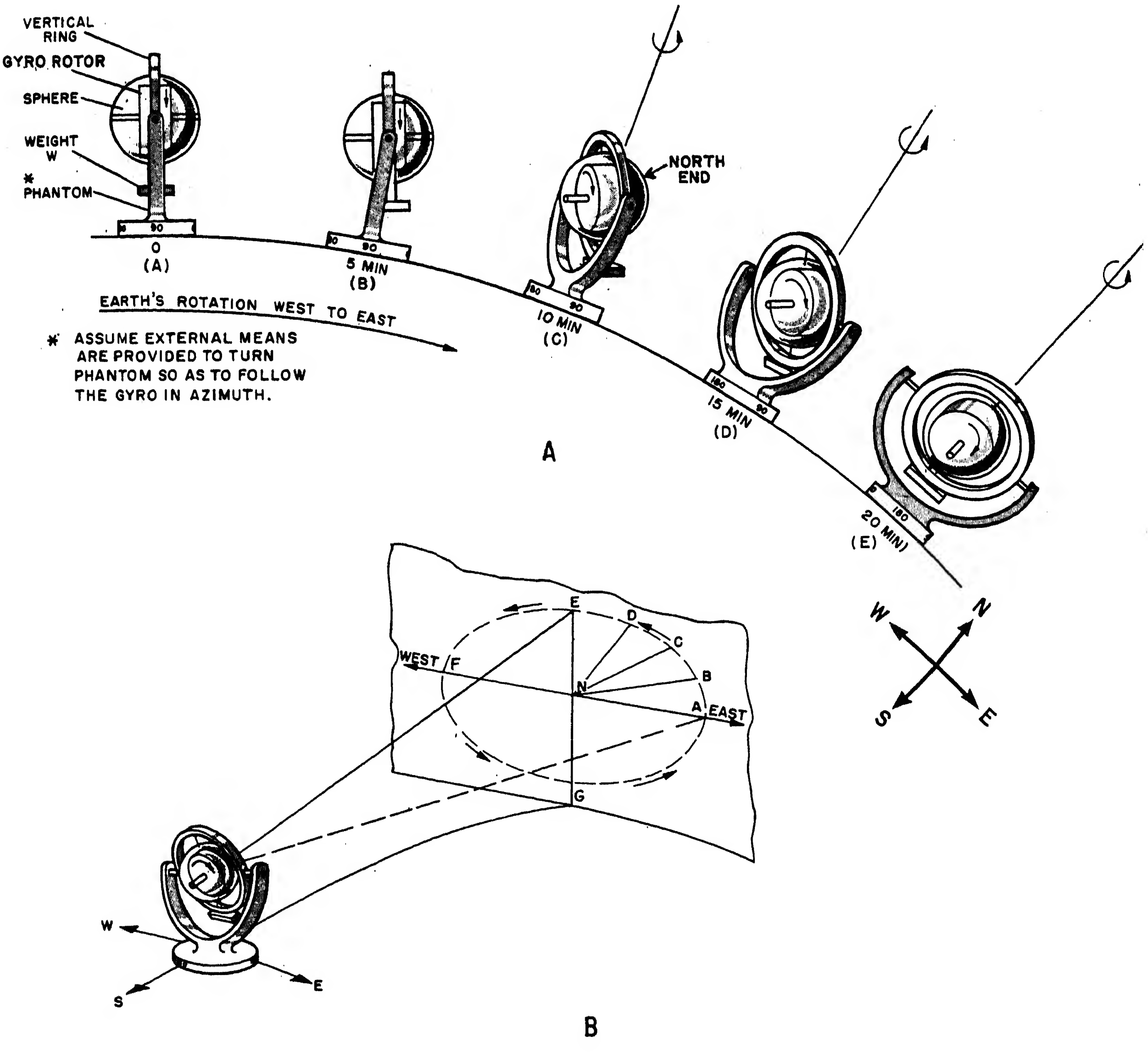

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Figure 12-12. — Effect of weight and earth's rotation on the gyroscope.

As the end of the gyroscope which was first pointing east (which will now be referred to as the north end) continues to rise due to the H.E.R., the torque on the gyro caused by the weight becomes greater since the moment arm through which the weight acts gets longer due to the greater tilt. As the speed of precession is directly related to the torque, the gyroscope turns about its vertical axis as shown at point D, figures 12-12A and 12-12B at an increasing speed until the axis is on the meridian (aligned north-south as shown at point E of figures 12-12A and 12-12B.

At point E of figures 12-12A and 12-12B, the gyroscope is aligned north-south, but the tilt, the torque caused by the tilt and the weight W, and the speed of precession are all at maximum; therefore, the gyroscope continues to precess past the meridian. As the north end of the gyroscope's spin axis crosses the meridian, the H.E.R. acts upon it and causes the tilt to start decreasing. As the tilt decreases, the rate of precession decreases. Finally, as a result of the H.E.R. the axle becomes horizontal and, since the weight on the vertical ring no longer produces a torque, precession stops. At this point (point F of figure 12-12B), the north axle has precessed as far west of the meridian as it was originally to the east of the meridian (point A of fig. 12B).

As the earth continues to rotate, the north end of the gyroscope spin axis starts to fall. The weight is raised against the forces of gravity on the opposite side of the gyroscope's horizontal axis, causing the gyroscope to precess back toward the meridian. When the gyroscope reaches the meridian (point G of fig. 12-12B), its north axle is tilted downward to a maximum degree and the torque from the weight cause it to precess past the meridian. As the north axle once again precesses to the east of the meridian, the H.E.R. starts to reduce the tilt. Finally, the gyroscope precesses back to its original starting point (point A of fig. 12-12B), while the H.E.R. has caused the north axle to be once again level with the earth's surface. At this point the gyroscope's north axle has completed one complete cycle, but H.E.R. continues to affect the gyro and causes its north axle to once again start to rise, and the weight causes the gyro to precess from east back toward the meridian (north). This cycle will repeat itself indefinitely with the gyroscope oscillating back and forth across the meridian from east to west and back again to the east.

By hanging a weight on the vertical ring of the gyroscope, the first requirement for making a gyroscope into a gyrocompass—making the gyro axle seek the meridian—has been fulfilled. However, some means must be provided to suppress the oscillations so the gyro wheel will quickly come to rest with its axle level in the north-south position.

SETTLING ON THE MERIDIAN

To suppress the oscillations of the gyro about the meridian a small weight is added to the sphere in which the gyro is housed. This weight (W_1) is placed on the east side of the gyrosphere in the position shown in figure 12-13. With the gyro spin axis level, the force produced by gravity acting upon weight W_1 and the gyroscope's vertical axis are perpendicular to the earth's surface and parallel to each other; therefore, no torque is exerted about the gyroscope's vertical axis by W_1. However, when the gyro tilts, due to H.E.R., the vertical axis of the gyroscope is no longer perpendicular to the earth's surface, and the force of gravity acting on W_1 imparts a torque about the vertical axis of the gyroscope. The torque about the gyroscope's vertical axis causes the gyroscope to precess about its horizontal axis. The net result of W_1 is to cause the gyroscope to precess about

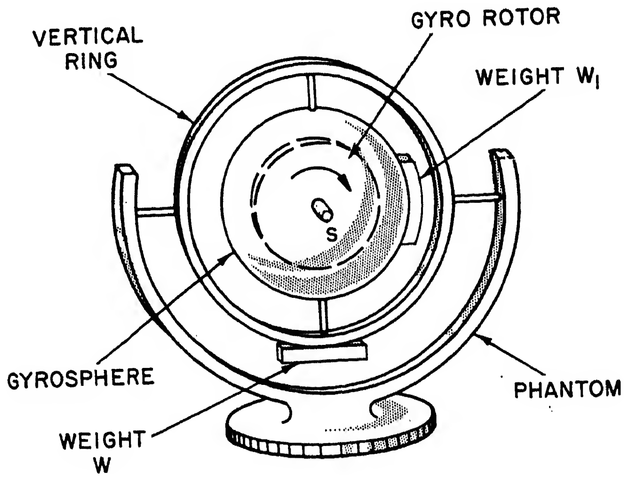

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Figure 12-13.—Gyroscope with weights on the vertical ring and sphere.

its horizontal axis in a direction that opposes the tilt caused by the effects of H.E.R.

Now, when placed on the equator aligned east-west, as a result of the leveling action of weight W_1, the gyro axle is not tilted upward as much when it reaches the meridian as it was with only weight W. Since the gyro axle is not tilted as much, the torque produced by weight W is not so great. Therefore, the gyro axle will not precess as far to the west of the meridian as it was east of the meridian when it was started.

After reaching the point where the axle is level and as far west of the meridian as it is going due to the action of weights W and W_1, the H.E.R. is still causing the axle to tilt downward. As a result, the forces due to the weights are reversed, and torques are created which precess the gyro to the east and upward. The same action takes place in the reverse direction. The gyro is not precessed as far to the east as it was to the west. Thus, the added weight W_1 causes the ellipse to be reduced each successive oscillation; the north end of the gyro axle will follow a spiral path as shown in figure 12-14 instead of the previous elliptical path.

A careful observation of the action of the two weights makes it apparent that the only position of rest that the gyro can find is with the gyro axle horizontal and on the meridian. In other words, the free gyroscope has been converted into a true north-indicating gyrocompass.

An instrument such as the one we have described will indicate true north accurately as long as it is located at the equator and is not transported over the surface of the earth. When this compass is relocated to a latitude other than the equator, the V.E.R., which was zero at the equator, will then affect the gyro and cause it to turn away from the meridian. When the gyrocompass is transported across the surface

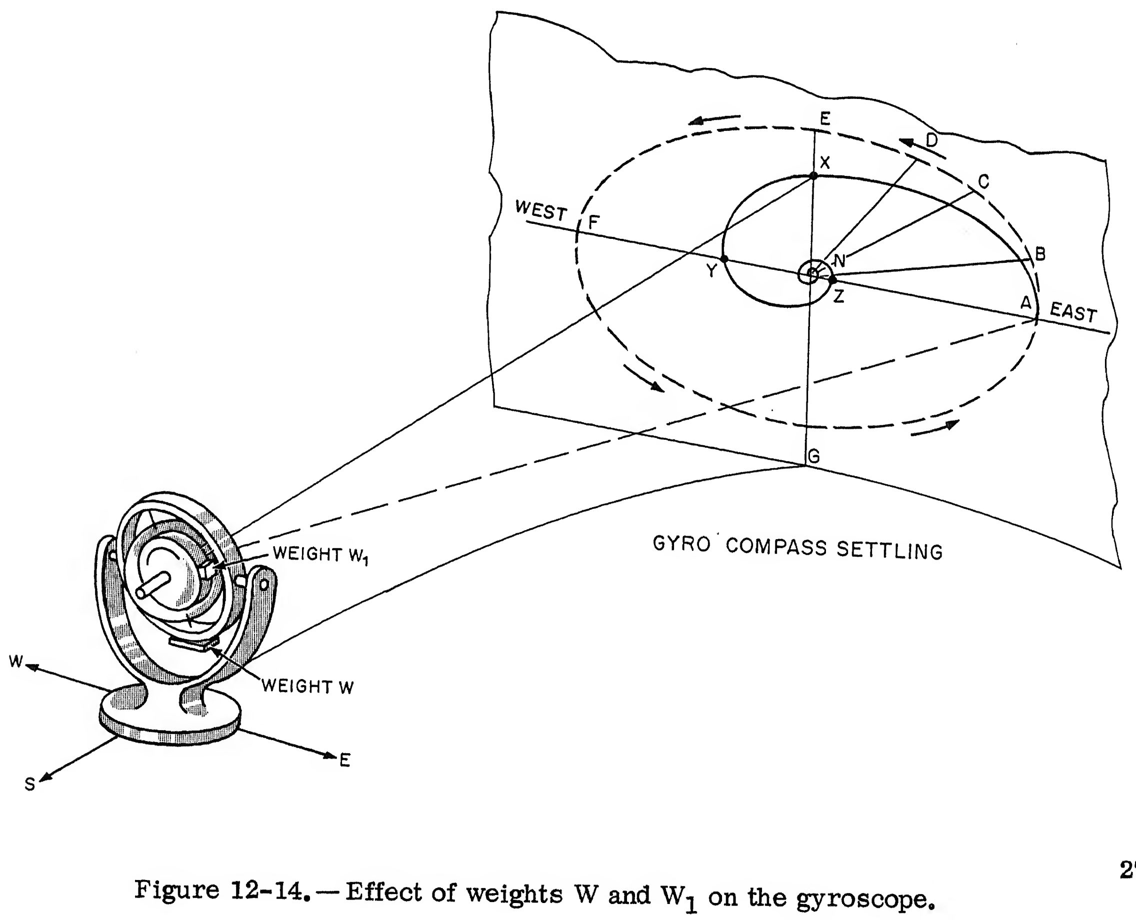

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Figure 12-14. — Effect of weights W and W_1 on the gyroscope.

of the earth, accelerations on the weights will cause torques on the gyro and precess it away from the meridian.

Many other outside forces affect the gyrocompass causing it to indicate directions (gyro errors) other than true north. The different types of gyrocompasses employed by the Navy compensate for or eliminate gyro errors in different ways. Some of the forces which produce errors may not affect a particular type of gyrocompass because the design of the compass negates the forces which produce certain errors. The other errors that cannot be eliminated are compensated for in different ways in different compass systems.

In the older mechanical compasses the errors that cannot be eliminated, through design or adjustment, are corrected by precalculating the error for a given set of conditions and, then, simply by shifting the lubber's line that amount necessary to correct the error. In other words, the spin axis of the older mechanical compass is very seldom exactly aligned on the meridian (true north), but rather is pointed to some location a few degrees either east or west of the meridian. Mechanical devices on the compass are used to crank in corrections to the compass for the forces that are causing the errors. The mechanical devices then shift the lubber's line (correct the compass) so that the compass indicates as though the spin axis were truly aligned on the meridian.

The electrical compasses take an entirely different approach to produce an accurate indication of true north.

The electrical gyrocompass uses an electronic control system to make it seek and indicate true north, vice the weights used on the simple gyrocompass. The force of gravity combined with the tilt of the gyro rotor as a consequence of H.E.R. are used as the controlling factors, as they were with the simple gyrocompass. However, instead of being used directly to control the compass, the force of gravity acts on a special device that generates an electrical signal that is proportional to the tilt of the gyro rotor. The signal from the device is amplified and used to apply torques electrically about the horizontal and vertical axes of the gyrocompass, and to cause the gyro's spin axis to settle on the meridian and level.

Devices within the electrical compass develop an electrical signal that produces a torque on the gyrosphere which is equal and opposite to those factors that would cause errors. In this way, the gyrosphere of the electrical compass is maintained level and on the meridian continuously.

The Mk 19 and Mk 23 are the electrical gyrocompasses which are rapidly replacing the mechanical compasses. They comprise the majority of the gyrocompass systems employed on Navy ships. In the next section of this chapter we shall discuss briefly the Mk 23 and Mk 19 gyrocompass systems, their principles of operation, capabilities, and nomenclature.

MK 23 GYROCOMPASS

The Mk 23 gyrocompass is a small electrical compass capable of withstanding severe operating conditions without sacrificing its primary function of furnishing heading data that is accurate enough for navigational purposes. The Mk 23 gyrocompass is used as the master compass on many of the patrol-type combatant vessels and on many of the larger auxiliary vessels. It is also sometimes used as a backup compass on some of the larger combatant ships.

MK 23 GYROCOMPASS PRINCIPLES OF OPERATION

Since the Mk 23 gyrocompass is an electrical compass, the force of gravity does not act directly on the gyro to make it align its spin axis on the meridian (north-south). For operation the Mk 23 relies on the gravity reference system, the followup system, and features that allow for correction of errors.

Gravity Reference System

The Mk 23 gyrocompass employs a special type level as its gravity reference system. The level, usually referred to as the electrolytic level, is similar to a carpenter's spirit level, except that it produces an electrical signal when not level with the earth's surface. As shown in figure 12-15, the level is attached to the vertical ring in such a way that it is parallel with the gyro's spin axis. Therefore, whenever the gyro's spin axis is not level with respect to the earth's surface, an electrical signal, which is proportional to the gyro's tilt, is produced by the electrolytic level.

The tilt signal from the electrolytic level is amplified and applied to the torquers, which magnetically apply torques about the gyrosphere's vertical and horizontal axes and cause precession.

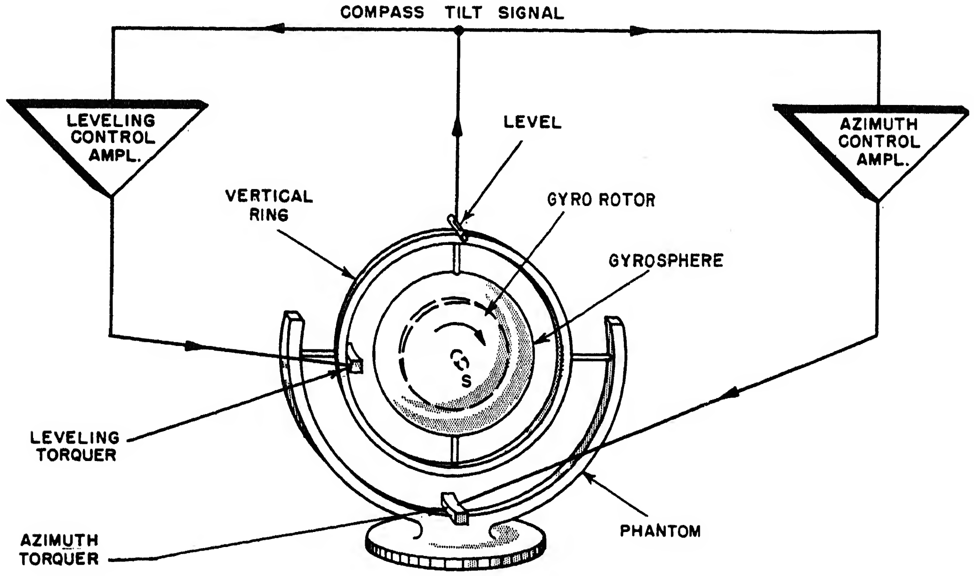

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Figure 12-15.—Simplified diagram of electrical azimuth and leveling controls.

The torquer (fig. 12-15) located about the gyrosphere's horizontal axis is known as the azimuth torquer. It applies a torque about the gyrosphere's horizontal axis proportional to the amount of tilt (detected by the electrolytic level) of the spin axis and causes the gyrosphere to precess in azimuth. The effect of this torque is the same as that produced by the weight W of the basic gyrocompass discussed earlier. When one end of the gyro axis is tilted upward, the resulting torque about the horizontal axis precesses the gyro in azimuth.

The leveling torquer, located about the vertical axis of the gyro (fig. 12-15), applies a torque about the vertical axis proportional to the tilt of the gyro spin axis (detected by the electrolytic level) and causes the gyro to precess about the horizontal axis to reduce the amount of tilt. The effect of the leveling is the same as that produced by weight W_1 attached to the east side of the gyrosphere of the basic gyrocompass. When one end of the gyro is tilted upward, the resulting torque, from the leveling torquer, about the vertical axis precesses the high end downward. The gravity reference system (level, amplifiers, and torquers) of the Mk 23 gyrocompass causes the compass to align itself with the meridian and permits elimination of the heavy weights used on the basic gyrocompass.

Recall that, when the basic compass was moved, the weights were acted upon by accelerations which caused errors in the gyro. The gravity reference system of the Mk 23 permits the gyrosphere and vertical ring to be perfectly balanced about the horizontal and vertical axes. Further, the vertical ring and gyrosphere are suspended in oil; their weight is adjusted so that they are weightless and balanced about both axes in the oil. Since the gyrosphere and vertical ring of the Mk 23 gyrocompass are weightless and balanced, they are not affected by the accelerations as was the basic gyrocompass.

The Mk 23 gyrocompass, described thus far, aligns itself on the meridian and is free from errors caused by accelerations on the gyrosphere. Still a better method of support must be devised and other errors must be corrected for before this compass is suitable for use aboard ship.

Followup System

Before the compass pictured in figure 12-15 is installed aboard a ship, a better means of supporting it must be devised. As we begin the discussion of the followup system of the Mk 23 gyrocompass, remember that the gyrocompass remains fixed in space, pointing constantly in the same direction (north) and that

the ship, in turning, rolling, etc., moves under the gyro.

The gyro pictured in figure 12-15 will function as long as its spin axis is aligned parallel with the ship's centerline and the ship is on a due north or south heading. In this case the ship's rolling motions will take place about the spin axis of the gyro, and the pitching motion of the ship will take place about the gyro's horizontal axis. As the ship turns to an easterly or westerly heading, the phantom and vertical ring will move with the ship while the gyrosphere will continue to point north. On a due east heading, the pitching motion of the ship would still take place about the gyro's horizontal axis, however, the rolling motion of the ship would now take place about the gyro's vertical axis. Any rolling motion of the ship would transmit torques through the vertical axis and cause the gyro to precess off the meridian.

The gyro we have just described has essentially lost one of its degrees of freedom (freedom to tilt) and can no longer be effective as a gyrocompass.

Also, for the gyrocompass to be useful, some method must be provided for indicating the ship's heading relative to true north and for transmitting this indication to the remote gyrocompass repeaters. If a data transmitting device (synchro) were to be attached directly to the gyrosphere to provide this information, the accuracy of the compass would be seriously impaired, if not destroyed. Such a data transmitting device would exert a torque on the gyrosphere, and cause precession of the gyrocompass off the meridian.

Both the above problems may be solved by using a followup system (fig. 12-16) to keep the phantom element aligned with the gyrosphere. As the ship turns under the gyrosphere, the phantom is kept in perfect alignment with the gyrosphere and in doing so the gyro retains its three degrees of freedom (spin, turn, and tilt). An electromagnetic device, called a followup pickoff, is attached to the vertical ring to detect any misalignment between the gyrosphere and the vertical ring. The followup pickoff emits an electrical signal proportional to the displacement. After amplification the signal drives a followup motor which repositions the phantom and vertical ring in respect to the gyrosphere and maintains them in alignment. In driving the phantom and vertical ring, the followup

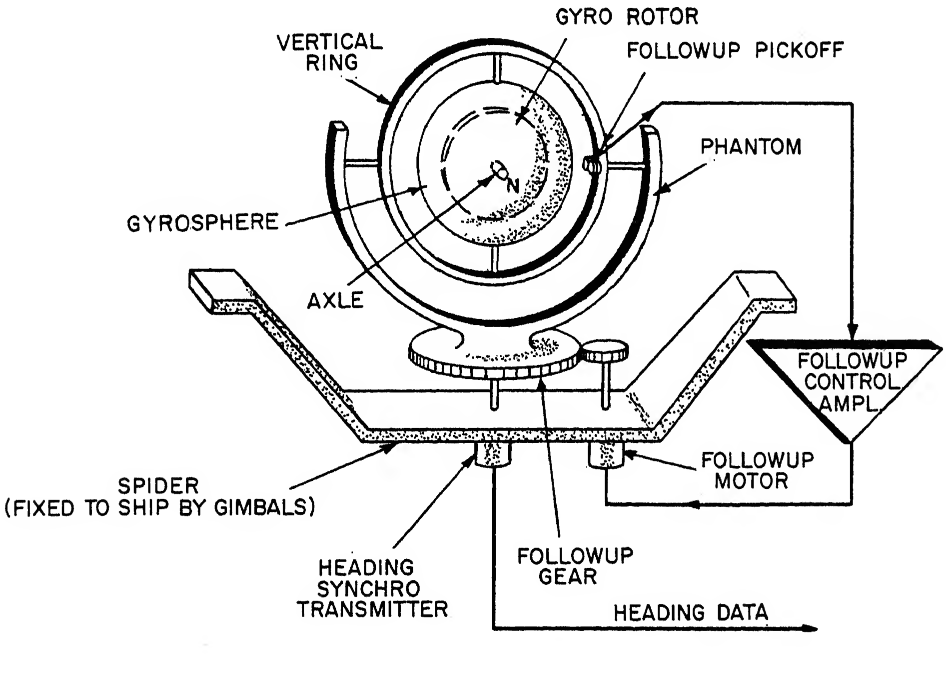

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Figure 12-16.—Simplified diagram of followup controls.

motor also positions the heading synchro transmitters. Thus, the heading data is provided without causing precession to the gyrocompass.

With the addition of the followup system, another means of supporting the gyrosphere, vertical ring, and phantom must be provided. This support, called a spider, is attached to the ship through gimbal rings (not shown in figure 12-16). Both the followup motor and the heading synchro transmitters are mounted on the spider. The gimbals support the spider in such a way that it remains level with the earth's surface regardless of the rolling and pitching motions of the ship.

Mk 23 Gyrocompass Errors and Correction

At points on the earth's surface (other than the equator) and aboard ships which are moving (not accelerations, but movement), certain factors are introduced which will result in errors if they are not compensated for or negated by the design of the compass.

VERTICAL EARTH RATE ERROR.—If a gyrocompass is placed on the meridian and level in northern latitudes, apparent rotation resulting from V.E.R., which is zero at the equator, will cause the gyro to turn about its vertical axis and point to the east of the meridian. Apparent rotation resulting from H.E.R., which has no effect on the gyro as long as it is on the meridian, will cause the gyro's north end to rise as soon as the gyro spin axle was out of plane with the meridian. The resulting tilt signal from the electrolytic level will be amplified, and the torquers will apply torques about the gyrosphere's vertical and horizontal axes to reduce the tilt and precess the gyro back to the meridian.

There are four factors causing motion of the gyro as just described. V.E.R., H.E.R., the leveling torquer, and the azimuth torquer. The V.E.R. and H.E.R. cause the gyro to turn away (error) from the meridian and unlevel it; they are constant factors for any given latitude. The second two factors, the leveling torquer and the azimuth torquer, attempt to precess the gyro back to the meridian and level it. The two torquers are actuated as a result of the tilt signal and depend upon it for their operation. As the torquers precess the gyro back toward the meridian, and as it approaches level, the tilt signal decreases. The decrease in tilt signal reduces the precessional force exerted by the torquers and, at some point before the gyro is precessed back to the meridian and level, the precession forces exerted by the torquers exactly balance the apparent movement of the gyro caused by the V.E.R. and the H.E.R. As a result, the gyro spin axis will settle with its north end up and to the east of the meridian in northern latitudes, and it will settle with the north end down and to the west in southern latitudes.

As the gyro is moved further north, the apparent rotation resulting from V.E.R. (maximum at the poles and zero at the equator) increases. Consequently, the gyro settles further to the east.

The small angle from the meridian at which the gyro axle settles varies with latitude. For this reason, a correction must be made to compensate for this error at any latitude where the compass may be used.

To prevent the occurrence of such an error, an adjustable electrical signal, proportional to the V.E.R. at the latitude where the gyro is located, is applied continuously to the azimuth control torquer, as shown in figure 12-17. This causes a precession of the compass at a rate exactly equal but opposite to that of the V.E.R. The compass with this signal will settle level on the true meridian and will remain so.

SPEED (MOVEMENT) ERROR.—When a gyrocompass is placed aboard a ship which is sailing a northerly course, the north end of the gyro which, because of rigidity, tends to remain fixed in space, will appear to tilt upward in relation to the earth's surface. For a practical test of this observation, point a pencil at a distant object and move the pencil over the surface of a ball. As you move the pencil in a direction simulating a northerly course, the north end of the pencil will appear to rise in relation to the surface of the ball. Conversely, if you move the pencil in a direction simulating a southerly course, the north end of the pencil will appear to fall.

The rate at which the gyro axle will tilt depends on the speed and direction of the vessel. For any given speed the tilt effect will increase as the course traveled becomes more northerly or more southerly. Any component of northerly or southerly speed will produce the effects listed above. There will be NO tilting of the gyro axle ONLY when the ship's course is due east or west because, only then, will the ship's velocity be entirely at right angles to the spin axis of the gyrorotor.

This tilting of the gyro spin axis, caused by traveling a northerly or a southerly course,

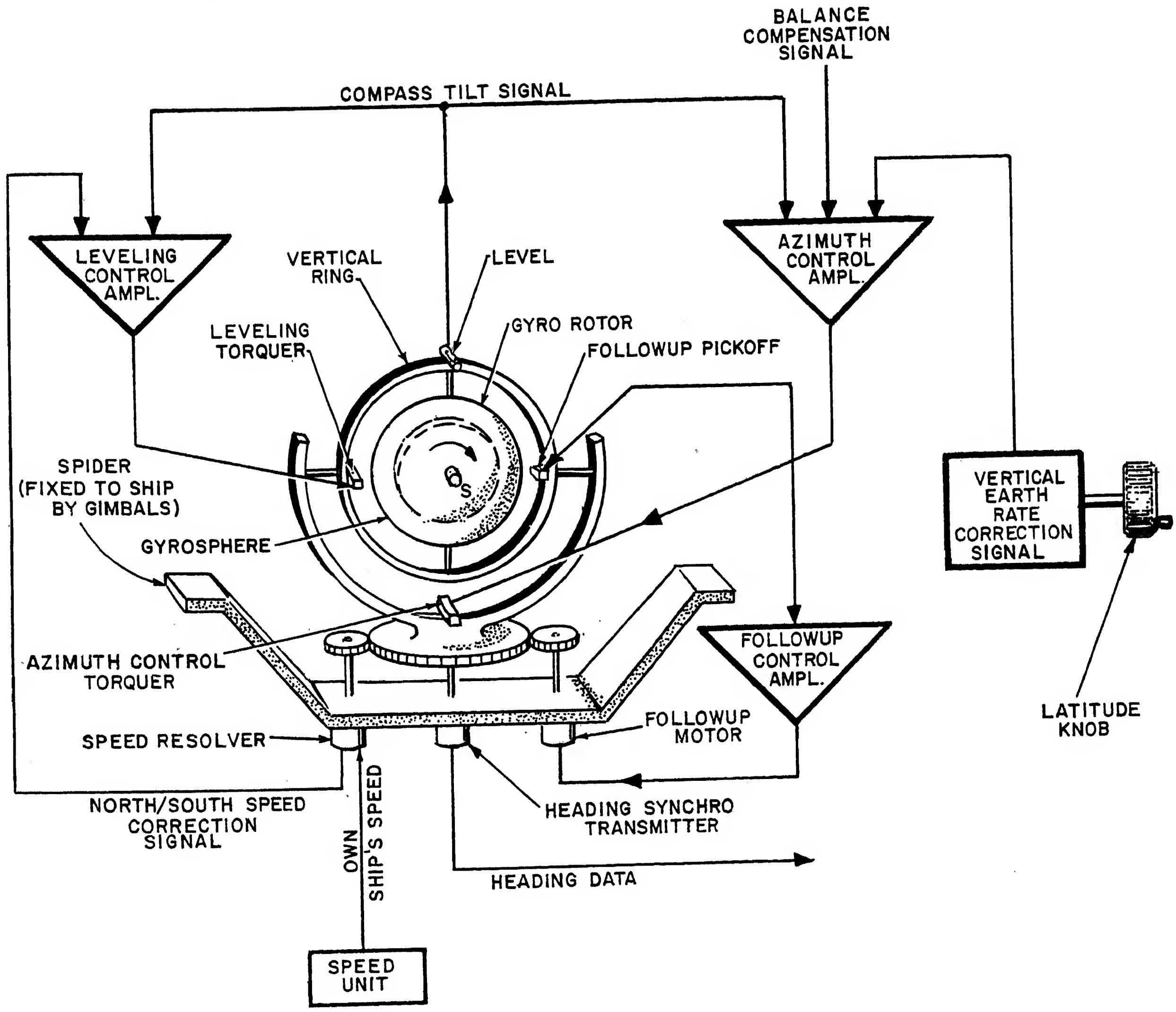

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Figure 12-17.—Simplified diagram of all controls for the Mk 23 gyrocompass.

affects the accuracy of the compass because the resulting tilt signal is amplified and applied to the torquers. For a northerly course the torquers precess the gyro off the meridian to its west, resulting in a westerly error. For a southerly course, the tilt signal from the level causes the gyro to be precessed to the east of the meridian resulting in an easterly error. If a torque were applied to precess the gyro axle downward at a rate equal and opposite to that which northerly or southerly speed is causing it to rise, the gyro would remain level and no azimuth error would occur.

The gyro error resulting from ship's northerly or southerly speed is eliminated in the Mk 23 gyrocompass, as shown in figure 12-17. An electrical signal proportional to ship's speed is furnished to the speed resolver, which is mounted on the spider, and the shaft of the resolver is positioned by the followup system. The resolver then resolves the electrical speed signal with the mechanical course input to produce an electrical signal equal to ship's speed multiplied by the cosine of the course, or north/south speed. The north/south speed signal is then applied to the leveling torquer to precess

the gyro downward at the same rate at which it is trying to rise due to the northerly or southerly speed. By correcting the gyro in this manner, there will be no azimuth error due to northerly or southerly speed, and the compass will remain level and on the meridian.

CONSTANT HORIZONTAL TORQUE ERROR.—Any constant torque about the horizontal axis of the gyro, such as that caused by an unbalance of the gyrosphere and vertical ring, will cause the gyro to settle with a tilt and an azimuth error. As stated previously, the gyrosphere and vertical ring are suspended in oil; weights are added or removed from the gyrosphere and vertical ring until they are weightless and balanced about their axes in the oil. However, it is very difficult to completely balance the gyrosphere and vertical ring in the suspending oil.

In the Mk 23 gyrocompass any torques resulting from the remaining unbalances can be eliminated by applying a variable electrical signal to the azimuth torquer so that the torquer produces a torque that is equal and opposite to the torque caused by the unbalanced condition.

In this section we have discussed the principles of operation of the Mk 23 gyrocompass. In principle, to this point, our Mk 23 gyrocompass accurately indicates north, has a followup system to keep the phantom aligned with the gyrosphere, can transmit heading data to remote indicators, is supported in a manner that is adequate for installation aboard ship, and has been corrected for any factors that might cause errors in the heading data it provides.

In the next section of this chapter you will find basic information on the equipment which comprises the Mk 23 gyrocompass.

MK 23 GYROCOMPASS EQUIPMENT

The original Mk 23 gyrocompass (Mod 0) has been modified several times since it was introduced for service in the 1950's. Most of the modifications have been minor in nature. The modification that resulted in the greatest change to the Mk 23 Mod 0 was the Mk 23 Mod C-3. We will discuss the equipment for both these systems so that you may compare the differences.

The Mk 23 Mod 0 and Mk 23 Mod C-3 gyrocompasses are compensated for speed error, V.E.R. error, and unbalance about the horizontal axis. The compasses are capable of indicating true north accurately in latitudes up to 75°N or S, or they may be used as a directional gyro when nearer the poles. An electronic followup system is provided which furnishes accurate transmission of heading data to remote indicators (repeaters).

The equipment which comprises the Mk 23 Mod 0 and the Mk 23 Mod C-3, figures 12-18 and 12-19, consists of the master unit, control cabinet, speed unit, alarm control unit, and visual alarm unit. The Mk 23 Mod C-3 has two additional units: the power supply unit and the power supply control unit. The control cabinets, their circuitry and, of course, the two power supply units comprise the major differences in the Mk 23 Mod 0 and Mk 23 Mod C-3. The other equipment, which make up the two gyrocompasses, is very similar with only minor differences.

Master Unit

The master units of the Mk 23 Mod 0 and Mod C-3 are very similar and consist (fig. 12-20) of a shock-mounted, oil-filled binnacle and the gyrocompass element. The unit is designed for deck mounting and weighs approximately 100 pounds.

The gyrocompass element (fig. 12-21) is the principal unit of the compass system and consists of the sensitive element, phantom element, and spider element. The sensitive element consists of the vertical ring and gyrosphere. The sensitive element is the north-seeking part of the compass.

The phantom element is supported on ball bearings, located within the spider, and rotates about the vertical axis of the gyrosphere. The phantom element is maintained in alignment with the sensitive element by the followup system.

The spider element supports the phantom, gyrosphere, and vertical ring assembly. The spider, in turn, is supported by the gimbal rings; the complete gyrocompass element is supported within the binnacle.

Control Cabinet

The control cabinets for the Mk 23 Mod 0 (fig. 12-18) and Mk 23 Mod C-3 (fig. 12-19) gyrocompasses contain the control devices, followup amplifier, azimuth control amplifier, leveling control amplifier, and other components necessary for the proper operation of the compass. Both control cabinets are very similar in operation. Their principal difference is that vacuum tubes are used in the Mod 0 control cabinet,

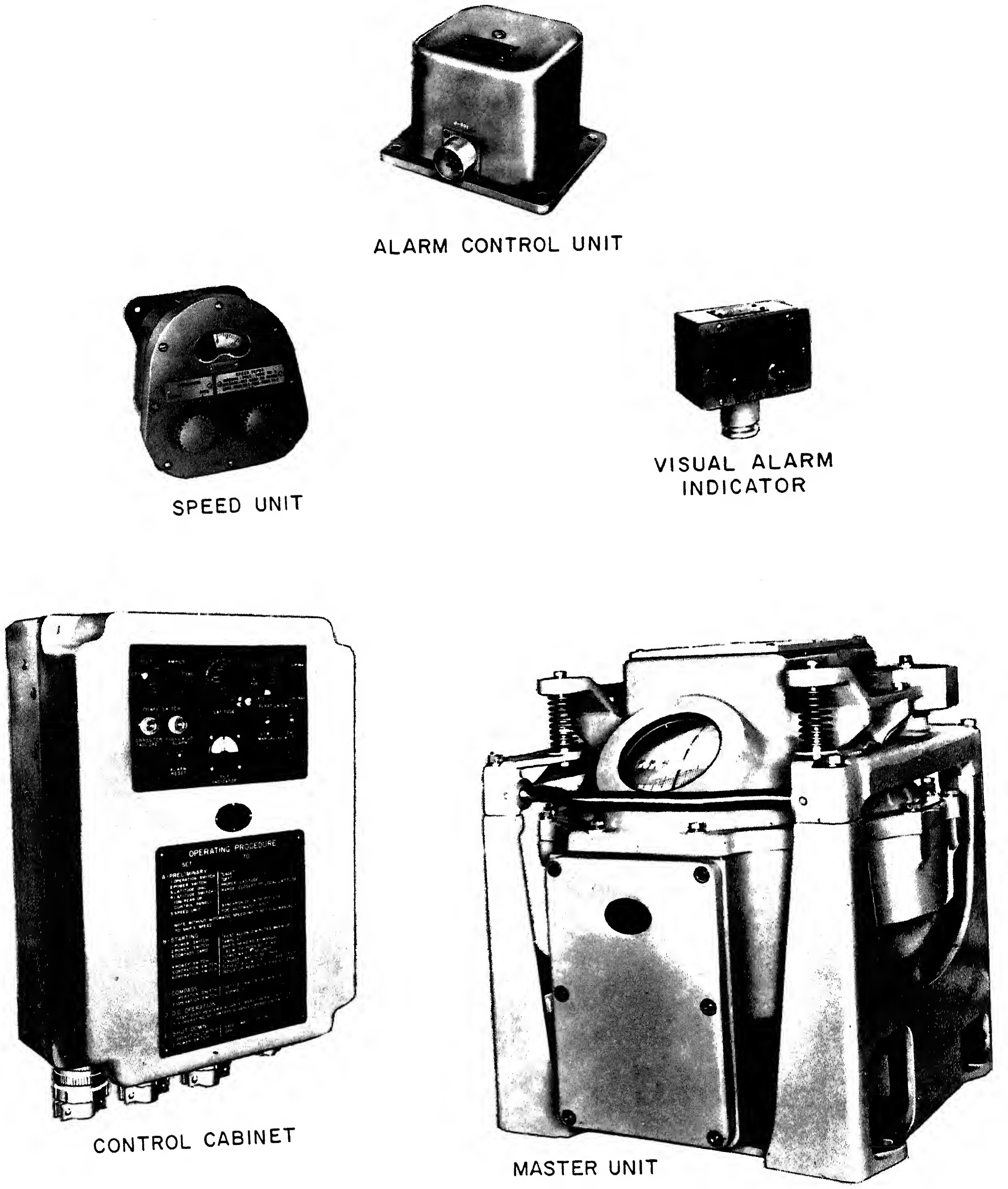

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Figure 12-18.—Mk 23 Mod 0 gyrocompass equipment.

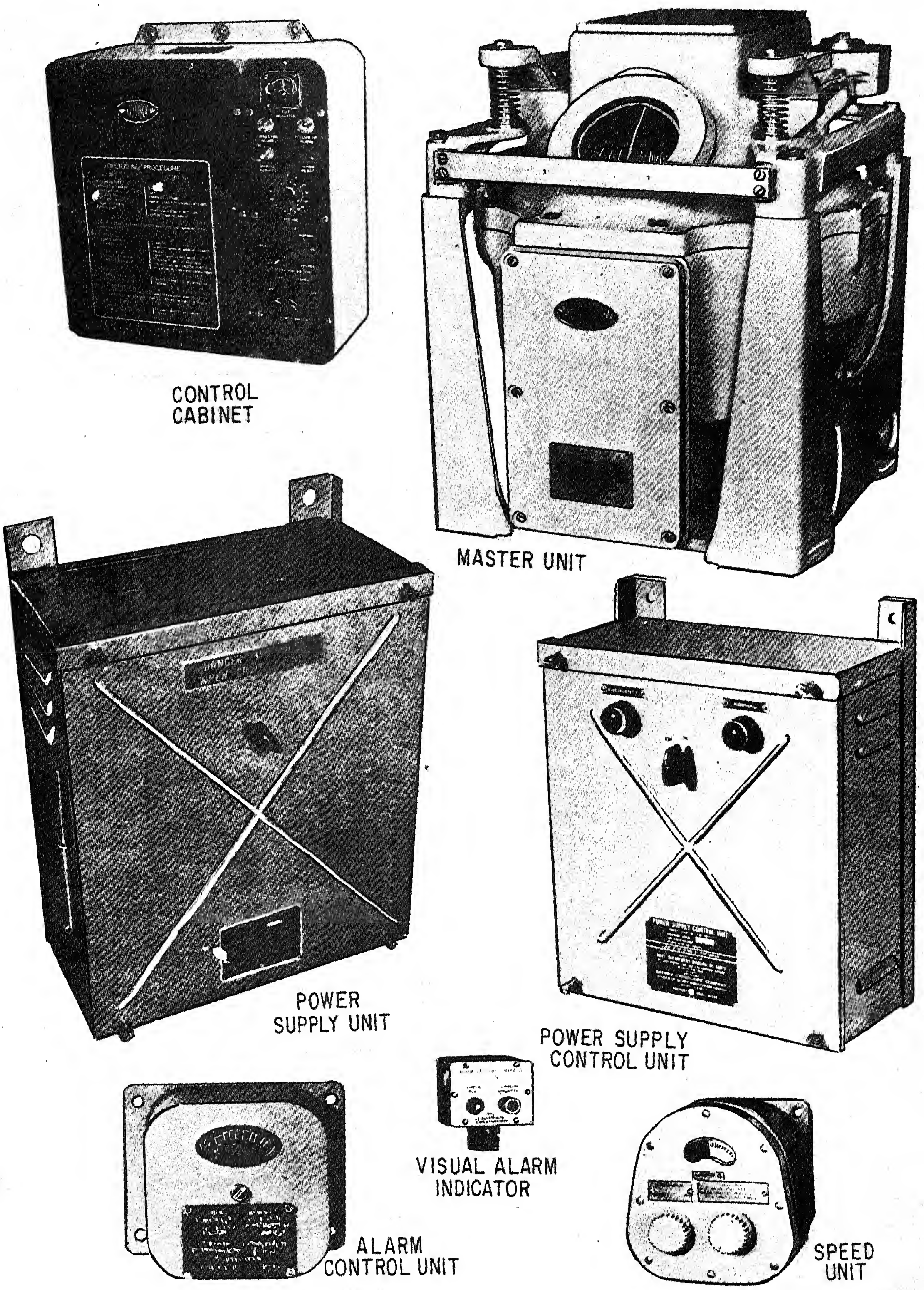

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Figure 12-19.—Mk 23 Mod C-3 gyrocompass equipment.

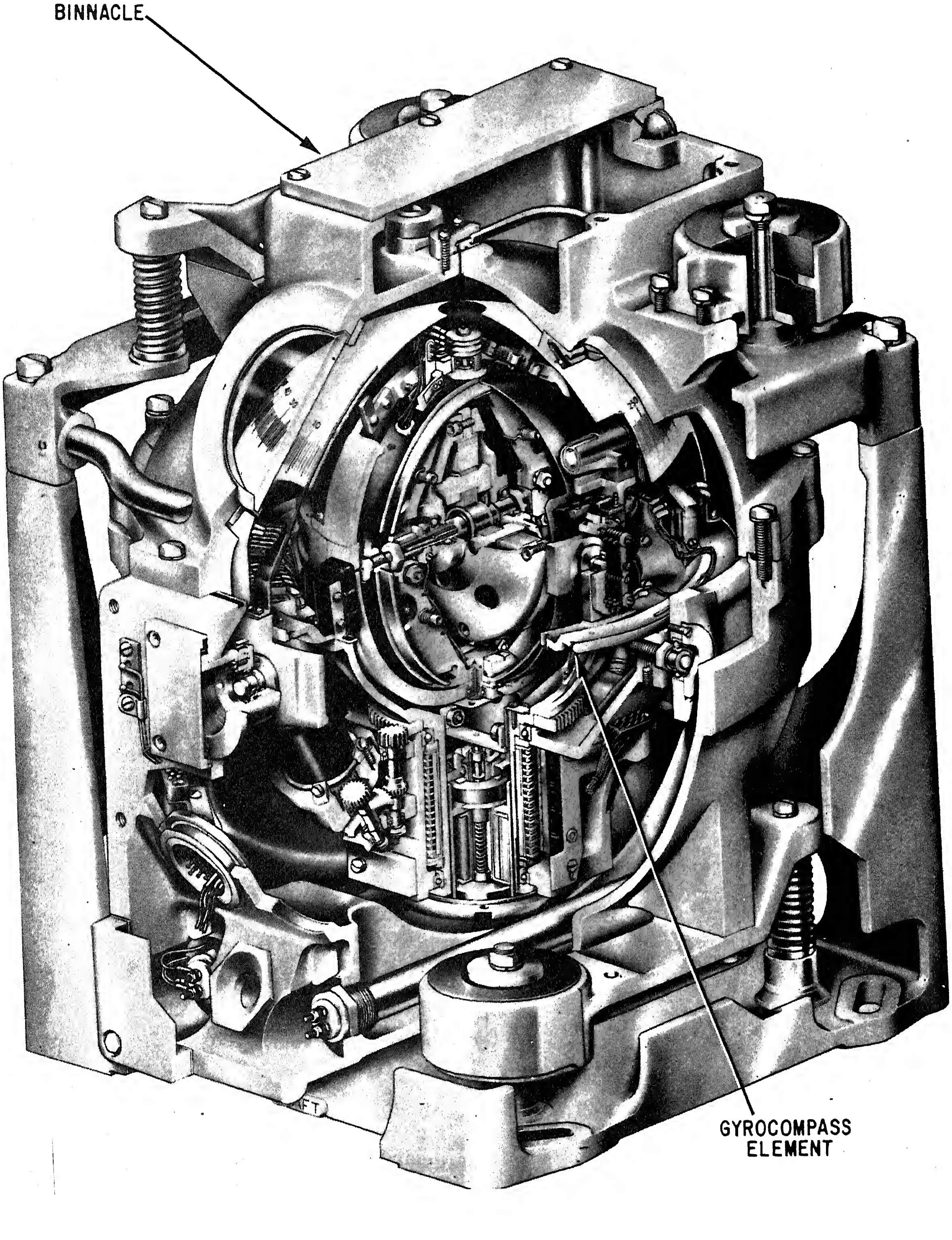

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Figure 12-20.—Mk 23 Mod C-3 master unit.

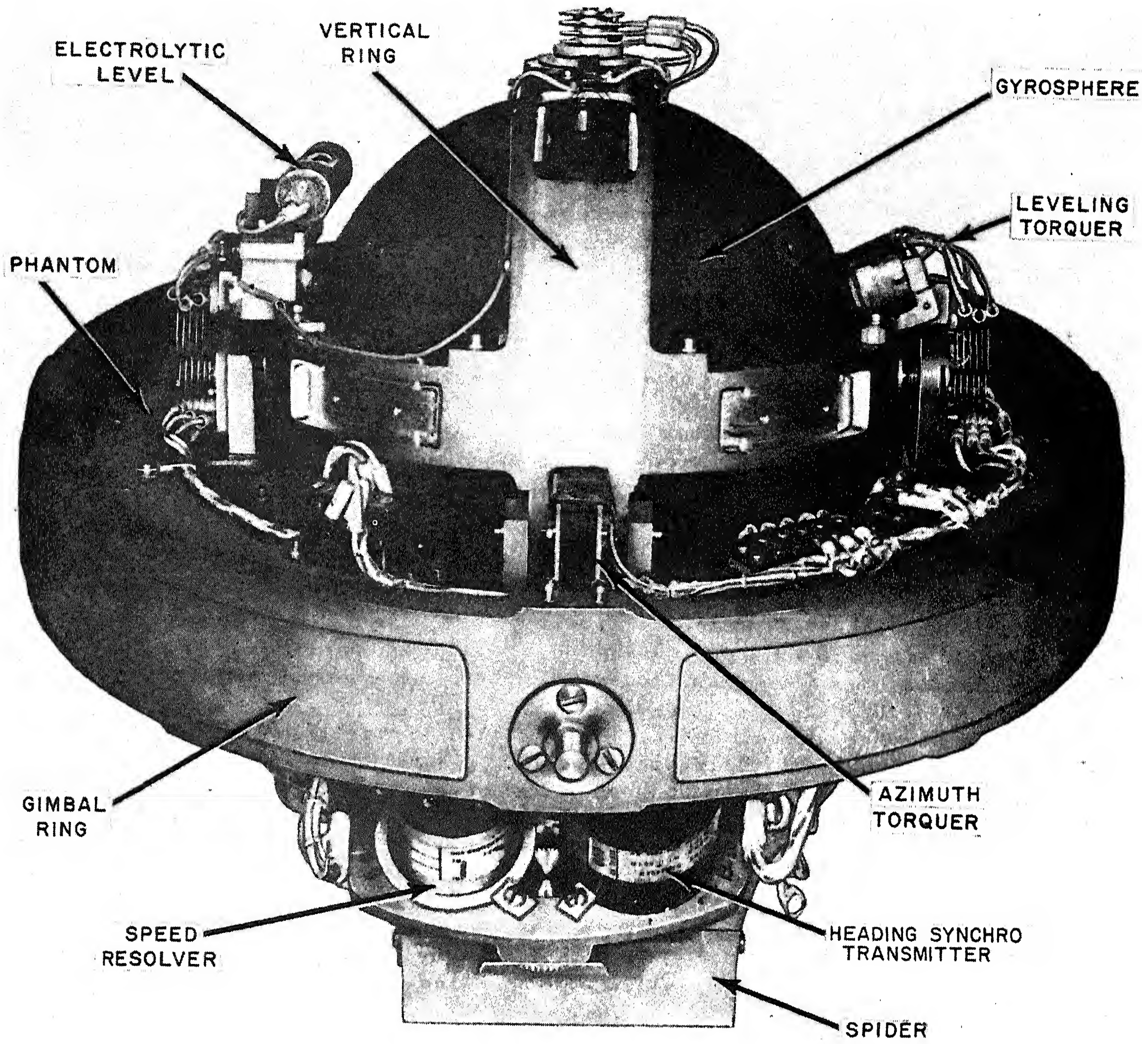

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Figure 12-21.—Gyrocompass element.

while solid state devices are used in the Mod C-3 control cabinet.

Circuits within both control cabinets make it possible for the operator to start and settle the gyrocompass on the meridian within 30 minutes vice the 4-hour settling time normally required. Other circuits permit the gyrocompass to be used as a directional gyro near the poles. In this mode of operation the gyro is aligned with an imaginary point (not the north pole) which is then used as the reference point for navigation in lieu of the north pole.

Instructions for starting and stopping the gyrocompass are located on the front of the control cabinet; more detailed instructions are contained in the manufacturer's technical manual.

Speed Unit

The speed unit, figures 12-18 and 12-19, contains the necessary components to produce

an electrical signal proportional to the ship's speed. Speed data are received from the ship's underwater log or can be set in manually. The speed range of the unit is 0 to 40 knots.

Alarm Control Unit

The alarm control, figures 12-18 and 12-19, contains the necessary relays and components to actuate a flashing light or alarm bell when certain portions of the system become inoperative.

Visual Alarm Indicator

The visual alarm indicator, figures 12-18 and 12-19, provides an indication of problems within the gyrocompass system. Under normal conditions the lamp on the indicator is lighted continuously. Flashing of the lamp, or if the lamp is out, indicates a failure within the gyrocompass system.

Alarm Bell and Annunciator

In some installations an alarm bell or electronic signal unit (chapter 8) is used instead of, or in conjunction with, the visual alarm indicator.

Power Supply Control Unit and Power Supply Unit

The power supply control unit and the power supply unit (fig. 12-19) together with a 120-VDC battery form a standby supply which provides the Mk 23 Mod C-3 gyro with an uninterrupted supply of 120-V, 400-Hz, 3-phase power. If the normal ship's supply fails, the two units, using the battery as a power supply, produce the 400-Hz power required to keep the compass operational for a limited period.

Mk 19 MOD 3 GYROCOMPASS

The Mk 19 Mod 3 gyrocompass is an electronic gyrocompass that furnishes heading data that is considered accurate enough (±0.3°) for navigational and fire control purposes. In addition to own ship's heading data, it accurately measures and transmits the roll and pitch angles of the vessel on which it is installed. This roll and pitch angle information is used to stabilize gunmounts, missile launchers, and other equipment which must remain level with the earth's surface to operate properly.

The Mk 19 Mod 3 gyrocompass is capable of operating accurately in latitudes up to 75°N or S. The Mk 19 Mod 3B, 3C, 3D, 3E, and some versions of the Mod 3A are capable of operating at higher latitudes or as directional gyros.

The Mk 19 gyrocompass is designed on the principle that two properly controlled horizontal gyros together can furnish a stable reference for the measurement of ship's heading, roll and pitch. The spin axes of the two gyros are maintained horizontal and in the north-south and east-west planes by the application of torques about the axis of both gyros.

Briefly, the compass (fig. 12-22) consists of two gyros placed with their spin axes displaced 90° from each other in a horizontal

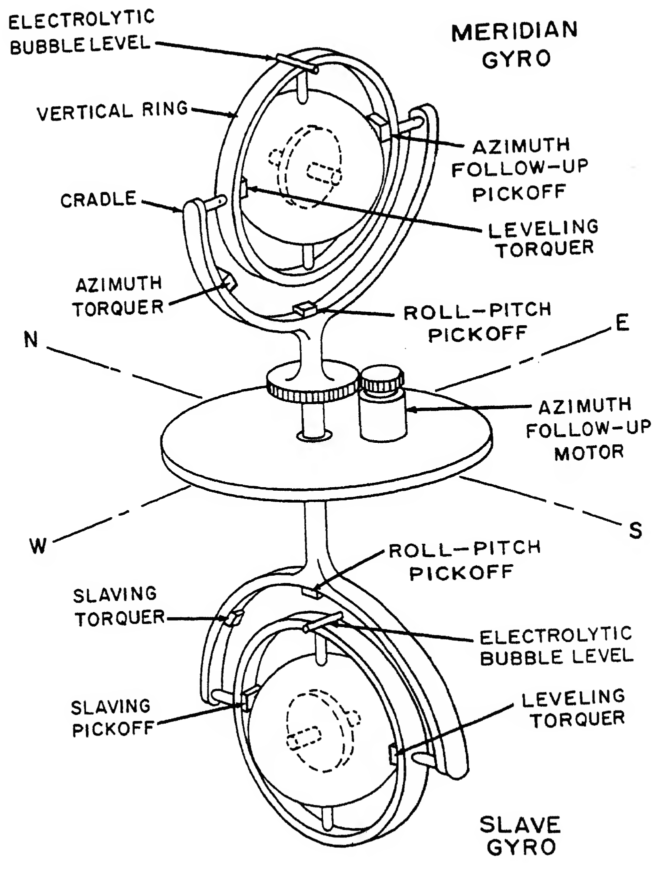

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Figure 12-22.—Simplified diagram of the Mk 19 Mod 3 gyrocompass element.

plane. The spin axis of one gyro is made to align itself north-south (meridian gyro); the spin axis of the other gyro is slaved (slave gyro) to the north indicating gyro so that it points in a direction 90° away from the first gyro (east-west). The meridian gyro and the slave gyro are mounted one above the other in a supporting ring. The ring is made to follow the gyros in heading and tilt by azimuth, roll, and pitch servos. These servos also drive the synchro transmitters which serve to supply roll, pitch, and azimuth (O.S.H.) synchro data.

The meridian gyro is essentially a conventional gyrocompass, which furnishes indications of azimuth as well as tilt about its horizontal axis. The slave gyro is essentially a directional gyro, which furnishes an indication of only tilt about its horizontal axis.

The compass is compensated for speed, acceleration, earth rate, and shift in balance.

An electronic control system is used in the Mk 19 Mod 3 gyrocompass to make it seek and indicate true north as well as the zenith. The electronic control system employed on the Mk 19 Mod 3, 3A, and 3B is very similar to that we described earlier for the Mk 23 gyrocompass. Later modifications of the Mk 19 (Mod 3C, 3D, etc.) employ an accelerometer instead of the electrolytic level as the gravity sensitive device in their gravity reference systems. Both the electrolytic level and the accelerometer measure the angle of the gyro's spin axis with respect to the earth's surface and provide an electrical signal when the axis is not level. This signal, after amplification, is used to apply torques electrically to settle the gyro on the meridian and level.

Both the meridian gyro and the slave gyro are enclosed in hermetically sealed spheres which are suspended in oil. The weight and buoyancy of the spheres are adjusted until they are weightless in oil.

The system consists of four major components: the master compass, control cabinet, compass failure annunciator, and standby supply. The Mk 19 Mod 3 and 3A employ a motor-generator type standby power supply, as shown in figure 12-23. The Mk 19 Mod 3B and later modifications employs a static-type standby power supply.

MASTER COMPASS

The master compass (fig. 12-24) consists of two major elements; the compass element and the supporting element.

Compass Element

The compass element includes the sensitive element (meridian gyro and slave gyro) and the phantom assembly. The phantom assembly includes: the azimuth phantom, which is maintained in north-south alighment with the meridian gyro by means of the azimuth followup system; and the roll-pitch, phantom, which is maintained level with the earth's surface by means of electrical signals from both gyros and the roll-pitch followup system.

Supporting Element

The supporting element includes the gimbals, the frame, and the binnacle. The gimbals permit the ship to roll about the sensitive element ± 60° and to pitch about the sensitive element ± 40°.

CONTROL CABINET

The control cabinet (fig. 12-23) contains the controlling devices, d.c. power supplies, analog computers, amplifiers, alarm system, and other assemblies required for operating and indicating the condition of the gyrocompass system. Some of the devices contained within the control cabinet include: the roll, pitch and azimuth followup amplifiers; the analog computer, which provides electrical signals that correct for those factors which could produce errors in the compass; and the starting control systems.

Starting Control Systems

To aid in starting and operating the master compass, two starting systems are provided—the fast-erect system and the fast-settling system.

The fast-erect system is provided to level both gyros when starting the compass.

The fast-settling system is employed to reduce the time required for the gyros to assume a true level position and for the meridian gyro to settle on the true meridian.

COMPASS FAILURE ANNUNCIATOR

The compass failure annunciator (fig. 12-23) is a remote visual indicator, similar to the one described for the Mk 23 gyrocompass. Not all installations aboard ship include the compass failure annunciator. The alarm systems for Mk

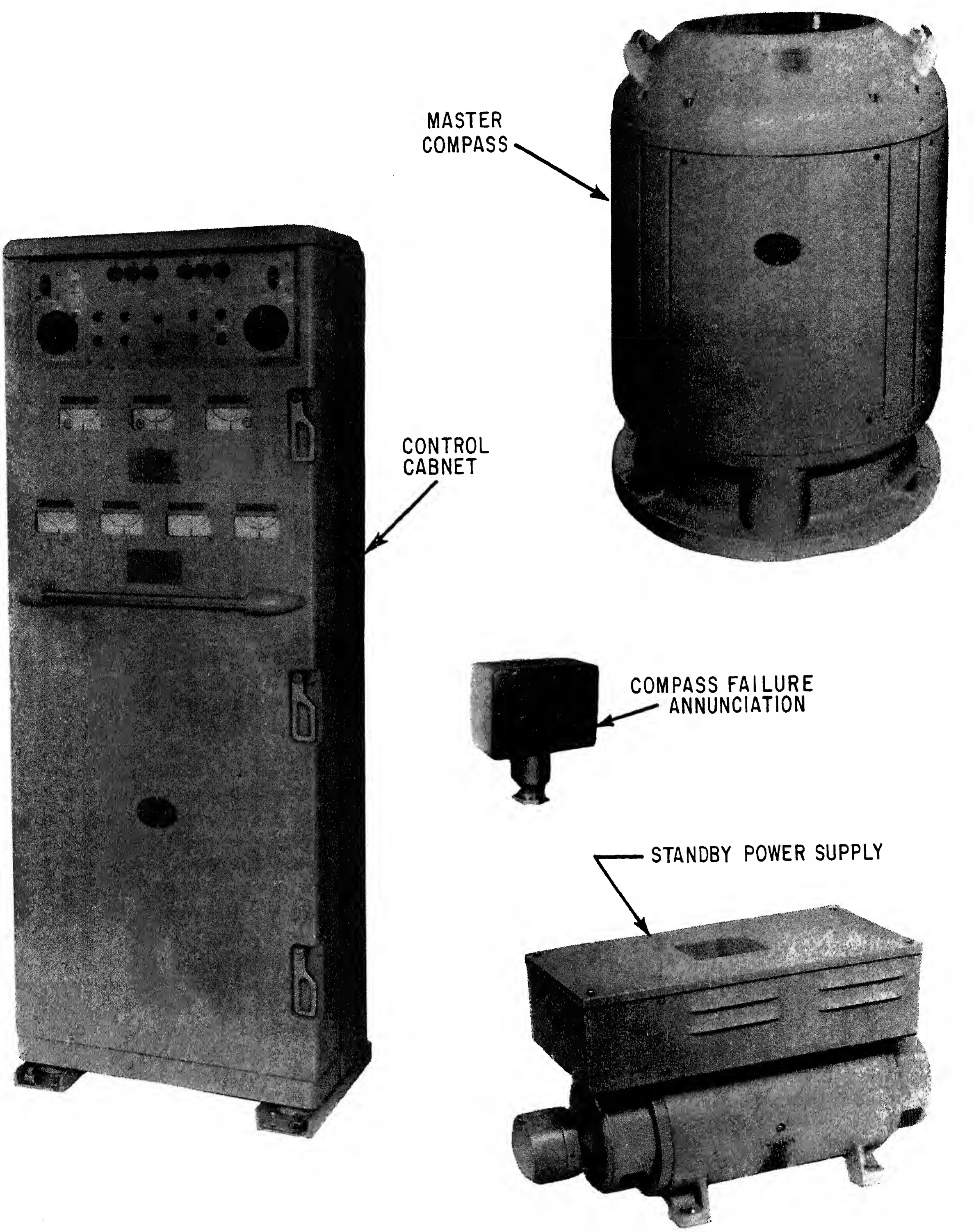

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Figure 12-23.—Mk 19 Mod 3 gyrocompass equipment.

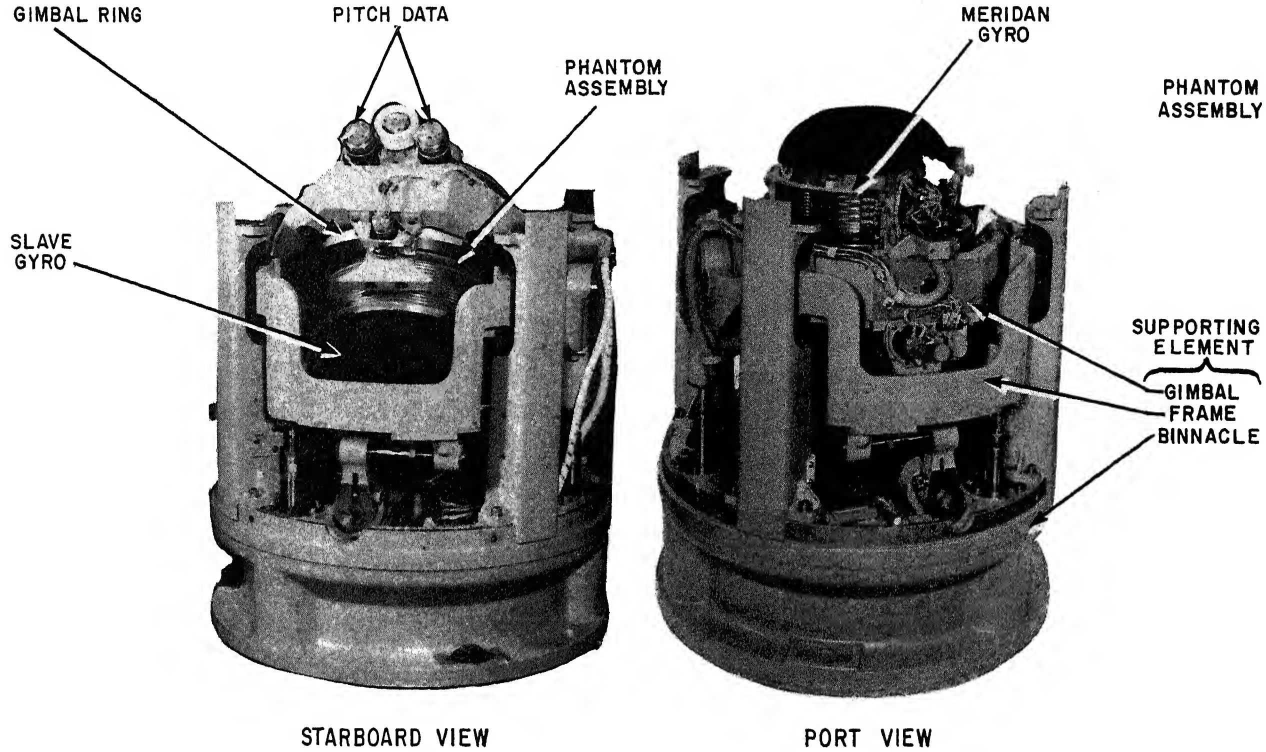

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Figure 12-24.—Two views of master compass (with covers removed) showing compass element and supporting element.

19 gyrocompass installations vary with each ship. Some type of audible alarm device is usually used in conjunction with the compass failure annunciator when it is installed.

STANDBY POWER SUPPLIES

The standby power supply (fig. 12-23) is a motor-generator set which provides emergency power to the Mk 19 Mod 3 and 3A compass systems, in case the normal ship's supply fails.

Under normal operation the standby power supply consists of a 115-volt, 400-Hz, 3-phase synchronous motor (a.c. section), driving a 120-volt, compound-wound d.c. generator, which charges a bank of twenty 6-volt storage batteries. If the ship's 400-Hz supply fails, or falls below 102 volts, the ship's line is disconnected automatically and the 120-volt d.c. generator operates as a motor powered by the storage batteries. The a.c. section now operates as a 115-volt, 400-Hz, 3-phase generator supplying the compass system. The standby power supply for the Sperry Mk 19 Mod 3B gyrocompass is a static unit with no moving parts other than relays. The standby power supply of the Mk 19 Mod 3C and above is a modified version of the Mk 19 Mod 3B standby power supply. The modified standby power supplies for these later modifications of the Mk 19 are referred to as static power supplies, and they are used as the primary power supply for the compass vice the ship's 400-Hz supply.

GYROCOMPASS RECORDS AND LOGS

The Gyro Service Record Book is provided with each gyrocompass. The book stays with its gyrocompass and is a record of the compass from its construction through its entire life cycle. The book contains acceptance, test, and installation data as well as information pertaining to the overhaul, repair, and inspections

of the gyrocompass. In the event a compass is to be removed from a ship, the appropriate entries are made in its Gyro Service Record Book, and the book is transferred with the gyrocompass.

Maintaining the Gyro Service Record Book is required by NAVSEA Systems Command. Instructions, procedures in case of its loss, etc. are found in the front of the Gyro Service Record Book and in Naval Ship's Technical Manual chapter 252 (9240.) Two pages are shown in figure 12-25. The page entitled "Inspection, Overhaul, and Repair" is completed and signed by the gyro electrician who completes the repair. In the event unfavorable conditions are found during an inspection by an off-ship facility, a report must be made to the commanding officer. Planned maintenance completed by ship's force personnel is recorded by normal PMS reporting procedures and is not recorded in this book. However, a fault found during PMS, and then repaired, will be entered in the Gyro Service Record Book, as well as reported through MDCS.

U.S. Navy Regulations and OPNAVINST 3120.32 assign responsibility for the care and maintenance of the gyrocompass equipment to the engineering officer and the electrical officer. The Gyrocompass Service Record Book contains items that are to be completed by the navigator. However, these are normally delegated and completed by either the engineering officer or the electrical officer who may also be designated as the gyro officer.

Some ships and type commands require that additional, locally prepared logs, records, etc. be maintained. If required, these records should be maintained completely and accurately and checked routinely by supervisory personnel. A major problem with all records is that, when neglected or when entries are omitted for any reason, they give a false record of reliability. Therefore, all records including MDCS documentation must be checked to ensure that they are dated, complete, and accurate.

Although not maintained by the electrical division personnel, the Magnetic Compass Record Book can be used to get data on the accuracy of the ship's gyrocompass system. This is a legal record required by Navy Regulations and OPNAVINST 3120.32 and is maintained by the quartermasters under the supervision of the navigator. It contains a record of the errors of the gyrocompass, the steering repeater, and the magnetic compass; entries are made every half-hour while the ship is underway.

GYROCOMPASS MAINTENANCE AND REPAIR

The gyrocompasses presently in use will give little trouble if they are properly maintained and if operator/repair personnel are properly trained, motivated, and supervised.

All persons associated with the gyrocompass installation should complete the applicable portions of the Personnel Qualifications Standards for that particular type of gyrocompass system. If correctly used, the PQS will ensure that personnel assigned to the operation, maintenance, and watchstanding duties have the knowledge necessary to adequately perform these duties. Supervision will ensure that personnel are carrying out these duties in the prescribed manner.

Corrective maintenance must be performed by knowledgeable personnel who follow the manufacturer's manual. Formal training on a particular gyrocompass system, although desirable, is not a necessity. The gyro electrician should, however, be thoroughly familiar with the manufacturer's manual and the installed system. The manufacturer's manual is the ultimate aid in all phases of training and repair. It contains sections devoted to the localization and isolation of malfunctions; therefore, all work must be conducted by persons familiar with these procedures. The manufacturer's manual not only indicates procedures that should be followed, but also warns of what cannot be done without causing further damage to the system. An improperly trained or careless repairman who is unfamiliar with, or is not following, the manufacturer's manual can easily cause additional problems. For example, the movement of a weight on a mechanical gyro or the turning of the wrong potentiometer in an electronic gyrocompass system can change a period or dampening setting which will require recalibration of the gyrocompass system at a shore-based repair facility.

All corrective maintenance and inspections conducted by outside activities must be recorded in the Gyro Service Record Book and through MDCS documentation to provide accurate indications of reliability, cost, and repair manhours. The PQS, PMS, and MDCS programs standardize training, documentation, and preventive and corrective maintenance. These programs, if properly implemented and supervised, will ensure the most effective and reliable operation of the gyrocompass system. If these programs are administered in a haphazard manner, equipment operation will deteriorate.

INSPECTION, OVERHAUL, AND REPAIR

Whenever inspections, overhauls, or repairs are made, the following information shall be entered below:

1. Date.
2. Results of the inspection.
3. Reason for the overhaul or repair.
4. Description of the work done.
5. Data and recommendations for future reference.
6. Repair activity.
7. Signature.

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DATA TO BE ENTERED BY NAVIGATOR

Name of gyro electrician ____________

Rate ____________

Experience ________ years ________ months.

Mark on scale of 4 ____________

Assigned compass duty (date) ____________

Relieved from compass duty (date) ____________

Cause ____________

REMARKS BY NAVIGATOR

DATA TO BE ENTERED BY NAVIGATOR

Name of gyro electrician ____________

Rate ____________

Experience ________ years ________ months.

Mark on scale of 4 ____________

Assigned compass duty (date) ____________

Relieved from compass duty (date) ____________

Cause ____________

REMARKS BY NAVIGATOR

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Figure 12-25.—Gyrocompass Service Record Book page.

GYROCOMPASS OPERATION

Because of its importance to the ship's safety during underway periods and in the operation and maintenance of weapons systems, standard gyrocompass operating procedures should be prescribed.

When the gyrocompass is started for any reason, an entry should be made in the Engineering Log. When the gyrocompass is started prior to getting underway, the station keeping the Preparation for Getting Underway Check-Off List (usually the quarterdeck) must also be notified. Prior to getting underway, usually when the Special Sea and Anchor Detail is set, entries should be made in both the Engineering Log and the Quartermaster's Notebook, indicating which gyrocompass (if more than one is installed) is the master (on line). While underway, the master will be changed only in the event of a casualty or with prior approval. The OOD must be kept fully informed of all of these changes. In the event of a casualty, the bridge must be notified immediately, and the engineering officer of the watch should be notified as soon as possible; both will be informed of the nature of the casualty which necessitated the change.

When the ship enters port, the gyrocompass systems should be secured only after permission has been obtained from the navigator and the commanding officer, via the engineering officer. Although not required for ship's safety, it may be advantageous to find out what requirements other departments have for the inport period, as many of their preventive maintenance procedures require gyro inputs. Mutual coordination and cooperation with other divisions which may require gyrocompass inputs while in port, will aid in the most efficient use of the system and also will keep operating hours at a minimum while still providing required services.

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U.S. GOVERNMENT PRINTING OFFICE: 1977-740-073/20